AN ANALYSIS OF CONTAINER BOOKING POLICIES FOR A CONTAINER STUFFING STATION

Thomas Russell Nelson

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

AN ANALYSIS OF CONTAINER BOOKING POLICIES
FOR A CONTAINER STUFFING STATION

by

Thomas Russell Nelson

September 1974

Thesis Advisor: J.P. Hynes

Approved for public release; distribution unlimited.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) AN ANALYSIS OF CONTAINER BOOKING POLICIES FOR A CONTAINER STUFFING STATION		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; September 1974
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Thomas Russell Nelson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		12. REPORT DATE September 1974
		13. NUMBER OF PAGES 77
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Naval Postgraduate School Monterey, California 93940		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The process of reserving space (containers) aboard vessels for transoceanic shipment is investigated. Controllable input variables to the system are discussed and analyzed in terms of defined performance variables, their interactions, and their impact on booking policy. The tradeoffs between these factors are looked at to show the possible alternatives with regard to a booking policy.

The various DOD commands involved with the booking process, their relationships and current booking policies are discussed. System interrelationships and operational tradeoffs among the performance variables are identified. Possible long-range solution techniques to the problem and a short run solution to aid a Container Stuffing Station in identifying its daily position with regard to booking are presented.

An Analysis of Container Booking Policies for a Container Stuffing Station

by

Thomas Russell Nelson
Lieutenant, United States Navy
B.S., United States Naval Academy, 1967

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
September 1974

ABSTRACT

The process of reserving space (containers) aboard vessels for transoceanic shipment is investigated. Controllable input variables to the system are discussed and analyzed in terms of defined performance variables, their interactions, and their impact on booking policy. The tradeoffs between these factors are looked at to show the possible alternatives with regard to a booking policy. The various DOD commands involved with the booking process, their relationships and current booking policies are discussed. System interrelationships and operational tradeoffs among the performance variables are identified. Possible long-range solution techniques to the problem and a short run solution to aid a Container Stuffing Station in identifying its daily position with regard to booking are presented.

TABLE OF CONTENTS

I. INTRODUCTION---------------------------------------9

II. BACKGROUND---------------------------------------17

A. CONTAINERIZATION WITHIN THE DEPARTMENT OF DEFENSE---------------------------------17

B. WESTERN AREA, MILITARY TRAFFIC MANAGEMENT AND TERMINAL SERVICE (WAMTMTS)-------------18

C. MILITARY OCEAN TERMINAL, BAY AREA (MOTBA)--20

D. TIDEWATER CONTAINER STUFFING STATION-------20

E. MILITARY SEALIFT COMMAND, PACIFIC (MSCPAC)-21

F. INTERACTION OF DOD COMMANDS----------------22

G. CURRENT BOOKING PROCEDURE------------------26

H. OPERATIONAL LIMITATIONS--------------------29

III. SYSTEM INTERRELATIONSHIPS AND OPERATIONAL TRADEOFFS--------------------------------------32

A. AGE, SINGLE CONSIGNEE PROPORTION, AND CUBE UTILIZATION TRADEOFFS-----------------36

B. AGE VS. CANCELLATIONS----------------------40

C. CUBE UTILIZATION VS. CANCELLATIONS---------42

D. AGE VS. QUANTITY ON HAND-------------------45

E. WORKLOADS AND CHANGES IN WORKLOADS---------47

IV. PROBLEM APPROACHES------------------------------49

A. PERFORMANCE UTILITY------------------------49

B. IMPLEMENTATION TECHNIQUES------------------54

1. Computer Simulation---------------------54

2. Queueing Model--------------------------55

3. Control Theory--------------------------57

4. Dispatch Model---------------------------59

C. INTERMEDIATE OPERATIONAL TECHNIQUES---------60

V. CONCLUSION-----------------------------------63

APPENDIX. SIMULATION DATA-----------------------65

LIST OF REFERENCES------------------------------75

INITIAL DISTRIBUTION LIST-----------------------77

LIST OF FIGURES

FIGURE

1 The Booking System---------------------------11

2 Supply and Transportation Cycle for Containers-------------------------------25

3 Current Booking Policy----------------------28

4 Booking Policy Model (Over Time)------------35

5 The Container Tradeoff----------------------37

6 Age-Cancellation Tradeoff (For a POD Over Time)---------------------------------41

7 Cube Utilization-Cancellation Tradeoff (For a POD Over Time)-----------------------43

8 Age-Quantity on Hand Tradeoff (For a POD Over Time)-----------------------46

9 Utility of Age and Cargo on Hand------------52

10 Queueing Model------------------------------56

11 Servomechanism Model------------------------58

LIST OF ABBREVIATIONS

BEP	Break Even Cost Points
CFD	Container Freight Division
CSS	Container Stuffing Station
FIFO	First-In-First-Out
LRU	Less Receipt Unit
MOTBA	Military Ocean Terminal, Bay Area
MSCPAC	Military Sealift Command, Pacific
MTMTS	Military Traffic Management and Terminal Service
POD	Port of Debarkation
POE	Port of Embarkation
RU	Receipt Unit
WAMTMTS	Western Area, Military Traffic Management and Terminal Service
WTCA	Water Terminal Clearance Authority

I. INTRODUCTION

Since the inception of a standing Army and the need for forces overseas, the Department of Defense has made extensive use of the high seas. As the American presence abroad has increased, so has the need for rapid, inexpensive, and relatively secure transportation of supplies and equipment.

The Department of Defense has relied heavily upon the maritime shipping industry for the movement of its cargo. As new and innovative methods are adopted by the maritime industry, the DOD has had to alter its methods of operation in order to keep pace. This is no more evident than in the area of containerization. DOD has been forced to comply with this concept in order to achieve the objectives of low cost, high volume shipping.

The military, having an increasing amount of its supplies containerized, has had to develop guidelines for managing, handling and transporting containers for an Army in the field. The problems faced by the Defense Department are complex and difficult because of the numerous and varied elements involved. If the Department of Defense is to take full advantage of the cost-benefits offered by containerization, it is essential that they examine all aspects of the containerized transportation problem.

One area of containerization that has not received much attention is the system-wide aspects of container booking, i.e., the process of reserving space (containers) aboard vessels for transoceanic shipment. This includes two areas. First is the booking policy or the set of guidelines that govern how the booking should be made and what factors should be considered in making that booking. Second is the booking procedure, or the mechanics of making a booking.

Many different activities are involved in the booking process. These include various DOD commands along with the various ocean carriers. These commands and their relationships are discussed in Chapter II.

An analysis of the operation of the Container Freight Division (CFD) at the Military Ocean Terminal, Bay Area (MOTBA) was made in order to identify those factors which are related to booking and thus impact on the operation of the Container Freight Division.

For analysis purposes, the booking system is characterized as having two sets of inputs and one set of outputs. The system is depicted in Figure 1.

The first set of inputs to the system are uncontrollable factors. These are factors that are external to the CFD and over which they have no control. These factors are:

(1) Cargo inputs: Cargo arrives at the Container Freight Division in a random fashion. Chapter II explains some aspects of cargo arrival and its unpredictability.

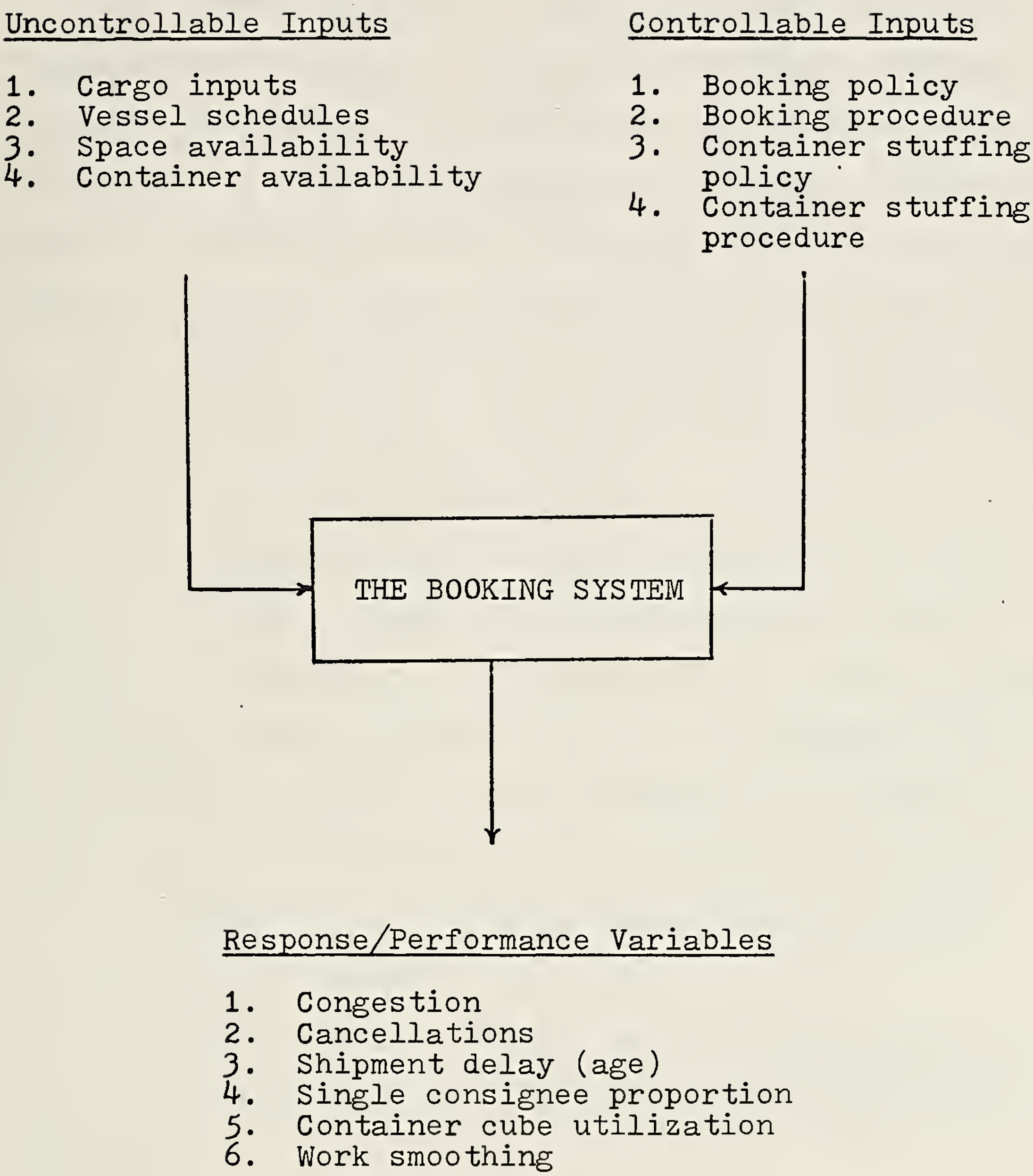


Figure 1: The Booking System

Actual cargo inputs are uncontrollable; however, forecasting procedures <u>can</u> be controlled.

(2) Vessel schedules: Vessel schedules are set by the commercial carriers. As one of the larger customers of most ocean carriers, the military can and does advise the carrier of desired scheduling and routing. The ocean carrier, motivated by profit, may make last-minute schedule changes in direct conflict with the military's requirements.

(3) Space availability: The Government has no direct, short run control over the amount of space that the carrier has available for government cargo.

(4) Container availability: Although booking space aboard a container vessel is synonymous with booking a container, there are some differences. The carrier, because of economic considerations, may keep his container pool to a minimum at a port. When a booking is confirmed, the containers may not be immediately available to the CFD.

The second set of inputs to the booking system are the controllable factors. These are:

(1) Booking policy: These are the system guidelines, such as a booking horizon of twenty-one days, which govern procedure.

(2) Booking procedure: The actual methodology of requesting space from a carrier through Western Area, Military Traffic Management and Terminal Service and the Military Sealift Command, Pacific. See Chapter II for details.

(3) Container loading (stuffing) policies: These are the general guidelines and restrictions which govern container stuffing.

(4) Container stuffing procedures: The actual methodology used for stuffing containers.

Outputs, in the form of response or performance variables, are generated from the above inputs. These are:

(1) Congestion: This term is used synonymously with quantity on hand. It can be either the average volume of on-hand cargo through a time period, or the volume of cargo on hand at a given point in time. Whenever the term congestion is used, the distinction will be made clear.

(2) Cancellations: A cancellation occurs when there is not adequate cargo to fill the space booked aboard a carrier. It is measured in terms of the number of containers booked but not utilized. It reflects the degree of overbooking (booking more space than can be utilized).

(3) Shipment delay (age): This is the average time between cargo arrival at the Container Stuffing Station and its departure from the station or port. It reflects the average delays experienced by users of the system. It can be measured on a shipment basis or a volume basis. When measured on a shipment basis, the total delay time for all shipments going to a port of debarkation (POD) is divided by the total number of shipments. When measured

on a volume basis, the average time is weighted by measurement tons (MT). Age can also represent the cargo age at stuff or time in terminal. In this case, it reflects the delay before a shipment is stuffed. Whenever the term age is used here, the distinction between volume and shipment age, terminal delays, and age at stuff will be made clear.

(4) Single consignee proportion: This variable is the volume proportion of cargo which moves in containers loaded solely with one consignee's shipments. It is calculated by dividing the volume of cargo which moved in single consignee containers by the total volume of cargo which moved to a POD during the time interval under consideration. It reflects the amount of cargo that does not have to be handled through a break bulk station at the POD.

(5) Container cube utilization: This is the average proportion of container space displaced by cargo. It is calculated by dividing the total volume of cargo by the total volume of the containers used to transport the cargo to the POD during the time interval under consideration. It reflects the actual amount of cargo stuffed with respect to the maximum amount of cargo that could have been stuffed under ideal conditions.

(6) Work smoothing: This term is used to describe the variations in the container stuffing operation workload from day to day or week to week. One way of measuring this is to compare the number of man-hours per day, or

per week, spent in stuffing containers with the average number of man-hours spent stuffing containers over a specified period of time. It reflects the variance in the day-to-day operations of the Container Stuffing Station.

The interactions between the input factors and the performance variables are extremely complicated. Nevertheless, on a theoretical level it would be possible to determine how controllable inputs influence performance variables, and, with precise objectives in mind, work toward optimal policies and procedures. However, on a practical level with limited resources, there does not appear to be a straightforward optimal solution to this problem because of several factors.

(1) There are a large number of factors affecting day-to-day operations which change rapidly due to shifts in government policies, transportation industry policies, and international situations.

(2) The uncertainty regarding the forecast of shipment arrivals at the Container Stuffing Station.

(3) The multitudes of alternative procedures that might be used in a booking policy and a corresponding inability to measure and scale these rules in a meaningful and coherent manner.

This thesis is concerned with analyzing the controllable variables in terms of the defined performance variables, their interactions, and their impact on a booking policy.

The tradeoffs between these factors are also looked at to show the possible alternatives with regard to a booking policy. Chapter II discusses the various DOD commands involved with the booking process, their relationships and current booking policies and procedures. Chapter III identifies system interrelationships and operational tradeoffs among the performance variables. Chapter IV presents possible long-range solution techniques to the problem and a short run solution to aid the Container Stuffing Station in identifying its daily position with regard to bookings. Appendix A presents data derived from a simulation model developed by Professor J.P. Hynes and used to assess some simple tradeoffs among alternative booking procedures.

II. BACKGROUND

A. CONTAINERIZATION WITHIN THE DEPARTMENT OF DEFENSE

It is not necessary in this paper to go into the detail of the history of containerization. That information is well documented throughout the literature. It is important, however, to examine containerization in the Department of Defense, and how material moves from consignor to consignee.

There are two general ways in which DOD manages cargo. Cargo handled as break bulk is sent directly to the port of embarkation (POE) where it is loaded aboard conventional cargo ships for trans-shipment. The other method of handling cargo, the one of interest here, is the process of containerizing cargo.

Cargo which is containerized can be either source stuffed, that is, the cargo is placed into containers at the consignor's dock, sealed, and shipped directly to a POE for lift aboard a container ship for ocean transport to the consignee; or it may be stuffed at a container stuffing station. Here cargo for particular POD's or consignees is collected and stuffed into containers after certain minimum volume restrictions have been met. These stuffing stations may be located near port facilities or many miles inland. As with source stuffed containers, after stuffing is completed, the containers are sealed and transferred

to a commercial shipping company for lift aboard container ships. The booking of source stuffed containers is not emphasized in this analysis because under current policies it is a trivial problem. Source stuffed container bookings are not sought until a consignor declares a specific need.

B. WESTERN AREA, MILITARY TRAFFIC MANAGEMENT AND TERMINAL SERVICE (WAMTMTS)*

Western Area, Military Traffic Management and Terminal Service is responsible for the transportation management of domestic and export shipments in the fourteen western states of Arizona, California, Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming.

Export cargo sponsored by the Department of Defense or other government agencies destined for overseas shipment falls under the cognizance of WAMTMTS. WAMTMTS is a jointly-staffed field organization under Headquarters Military Traffic Management and Terminal Service (MTMTS), Washington, D.C. WAMTMTS is located at the Oakland Army Base, Oakland, California, and is staffed by military personnel of the three services and civil service employees.

The mission of WAMTMTS is to:

(1) command assigned installations and activities;

---

*As of August, 1974, WAMTMTS was changed to Western Area, Military Traffic Management Command (WAMTMC). Any references to MTMTS throughout this thesis will mean MTMC.

(2) provide for area-wide implementation of MTMTS single manager responsibilities for traffic management, ocean terminal operations and related transportation services involved in the movement and transhipment within and through CONUS of cargo sponsored by the Department of Defense and other government agencies;

(3) develop and maintain plans for operational readiness under mobilization, emergency, or special contingencies;

(4) train related military units, military personnel, and civilians as assigned; and

(5) provide administrative and logistic support to tenant and satellite agencies.

With regard to mission two above, WAMTMTS serves as the Water Terminal Clearance Authority (WTCA) for the fourteen western states. All export cargo, with the exception of that which is to be airlifted, destined for shipment to installations within the Pacific area must be cleared for export by the WTCA. The Export Control Division of WAMTMTS is the organization that specifically serves this function.

All export cargo for the Pacific area is routed to one of three Military Ocean Terminals on the West Coast. Military Terminal Unit, Pacific Northwest, Seattle, Washington (PNW), handles export cargo from Puget Sound. Southern California Outport, Long Beach, California (SOCAL), is charged with the responsibility for export cargo

departing CONUS from the Southern California area. Military Ocean Terminal, Bay Area, Oakland, California (MOTBA), controls the export cargo from the San Francisco Bay and Northern California.

C. MILITARY OCEAN TERMINAL, BAY AREA (MOTBA)

Originally established to consolidate the terminal facilities of the Army and Navy in the San Francisco Bay Area, Military Ocean Terminal, Bay Area (MOTBA) is the largest operating element of WAMTMTS. Operating two large terminal facilities at the Oakland Army Base and the Alameda Reefer Facility, it controls seven deep water berths in addition to an 84-acre tidewater container stuffing area located on the Oakland Army Base. The ports of Stockton, Sacramento, and Eureka also fall under MOTBA's control.

D. TIDEWATER CONTAINER STUFFING STATION

The Container Stuffing Station (CSS) operating under the Container Freight Division (CFD) at MOTBA is responsible for loading containerizable cargo into ocean shipping containers that are then transferred to commercial shipping companies for overseas shipment.

For the most part, cargo remains in the warehouses until shipping vans can be obtained from a commercial shipping company. These vans are not received until space is booked aboard a specific vessel with a known sailing date. Some military shipping containers are used, but most is transported in commercial containers.

The Container Stuffing Station is operated by a civilian firm hereafter called the Contractor. The Contractor is under government contract to manage and operate the CSS operation of the Container Freight Division.

E. MILITARY SEALIFT COMMAND, PACIFIC (MSCPAC)

The Military Sealift Command (MSC) was established to bring together under a single agency the various ocean transportation resources of the Department of Defense. As the single manager operating agency for ocean transportation, MSC has the missions of:

(1) providing an immediate sealift capability in emergencies;

(2) planning for expansion in emergencies;

(3) providing peacetime ocean transportation for the Department of Defense and other authorized agencies; and

(4) providing ships for oceanographic exploration, range instrumentation, missile tracing, etc.

The relationship of MSC with MTMTS is especially close in the CONUS area commands because military cargo flows to MSC through the movement control channels of MTMTS. This is probably even more true in the case of container movements because the container can be considered or treated as an extension of the ship into land movements or an extension of land movements into ocean movements.

F. INTERACTIONS OF DOD COMMANDS

The various commands must interact in such a manner as to provide timely and cost effective delivery of material.

It is necessary to further break down the type of cargo being considered in order to understand the interactions involved. As already stated, break bulk cargo and source stuffed vans are not the principal focus of this analysis.

Cargo passing through the Container Stuffing Station can be classified as either release unit (RU) or less release unit (LRU) material. RU material is primarily cargo in lots greater than ten thousand pounds and special categories, such as classified cargo, as defined in Transportation and Travel, Military Traffic Management Regulation (AR55-355).

Release unit material requires positive export traffic release in accordance with DOD Regulations 4500.32-R, Military Standard Transportation and Movement Procedures (MILSTAMP). When a shipper has cargo, either break bulk or containerizable, meeting the criteria for RU procedures, he must request clearance from a Water Terminal Clearance Authority (WTCA) to move that material prior to actually moving it to the ocean terminal for lift. WAMTMTS, Export Control Division, serves as the WTCA for the fourteen Western states.

In the case of break bulk cargo, when WAMTMTS receives the request for clearance specifying space requirements,

they make an offering to MSC to book the material aboard an ocean carrier. Once positive booking is received, WAMTMTS releases the material, i.e., notifies the shipper that a positive booking has been made and that he may ship the cargo to a designated port of embarkation for lift aboard a break bulk vessel.

In the case of containerizable cargo, the shipper will specify how much space is required, how many containers are required, and what size containers. The space figure is included in case the carrier does not have available the size of containers specified. He can then substitute different size containers equal to the same space requirements. When WAMTMTS receives the clearance request, they make an offering to MSC for both the specified containers and the space. MSC books the space aboard a vessel and notifies WAMTMTS of the vessel sailing date, the date the containers have to be at the port of embarkation for lift, and the number of containers booked. WAMTMTS then notifies the shipper that the booking has been made and passes the booking information to the shipper. The shipper must then contact the carrier and specify when and where he wants the empty containers positioned for stuffing. The carrier provides the shipper with the necessary containers, which are stuffed by the shipper in a manner that insures they will be at the designated point of embarkation in time to be lifted aboard the designated vessel and meet that vessel's sailing date.

Less than release unit shipments are cleared based on the management by exception principle. They are allowed to flow freely into the Container Stuffing Station at MOTBA without prior clearance. The Container Freight Division then requests space from MSC via the WTCA. In this sense the CFD is a shipper.

Although LRU material accounts for only 10-15% of the tonnage passing through MOTBA, it accounts for 80% of the shipments, and this is at the heart of the booking problem for the Container Freight Division. The important factor to remember is that LRU material does not require a positive release into the transportation system and hence the volume of cargo is not controlled and an unknown factor to the Container Freight Station, MOTBA, WAMTMTS and MSC.

That segment of the DOD transportation system which is to be considered is depicted in Figure 2. Roughly twenty percent of the general cargo moving to Pacific Command follows this pattern.

The following actions occur at each step in the procedure:

(1) The user who will become the ultimate consignee submits his requisition that is to be filled by the shipper. Supply control points are not considered users in this system.

(2) The shipper ships the requisitioned material directly to the CFD of MOTBA if the material is less than receipt unit (LRU).

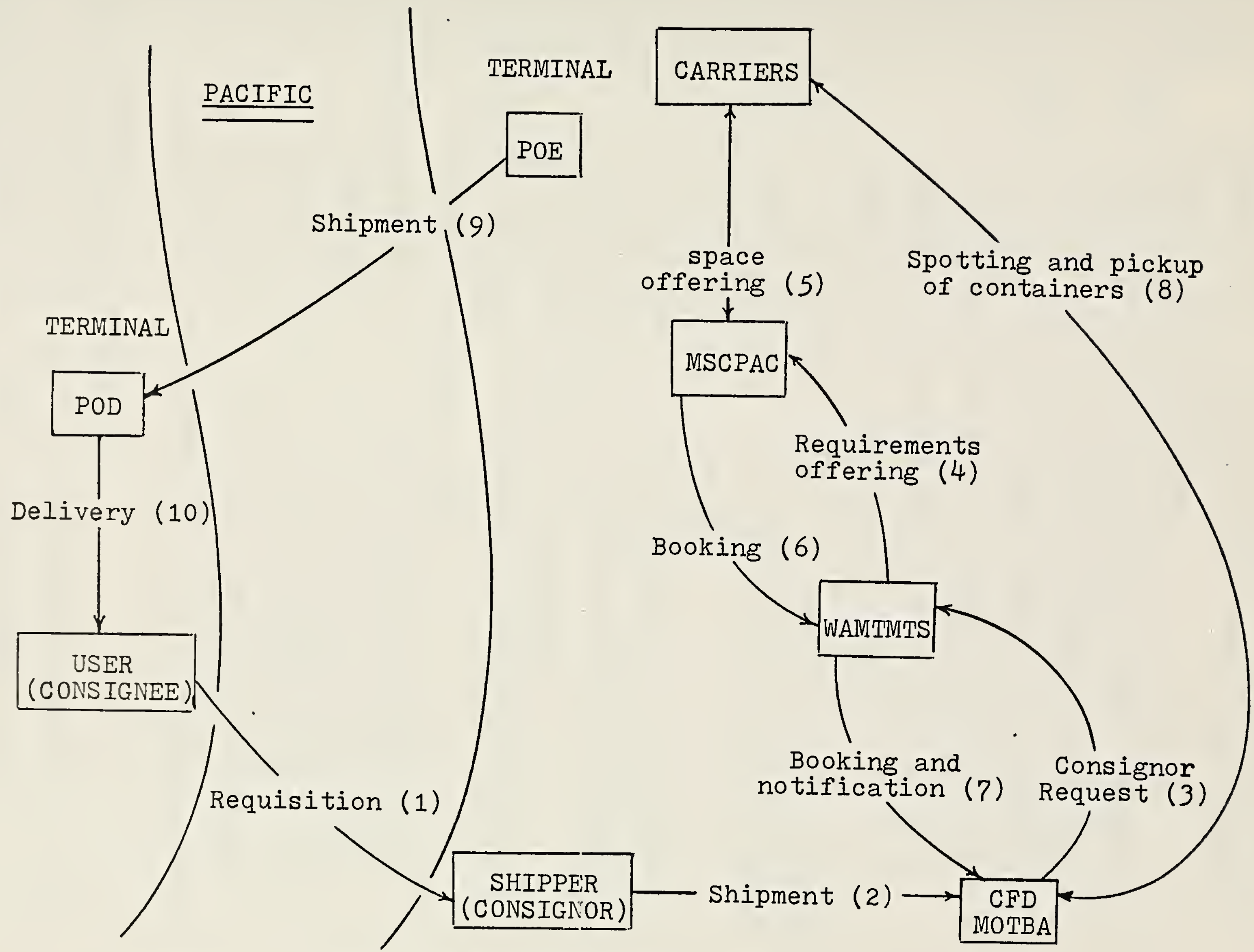


Figure 2: Supply and Transportation Cycle for Containers

(3) MOTBA offers its requirements for containers to WAMTMTS in accordance with the Military Traffic Management Regulations.

(4) Shipment data, as extracted from this request, is processed and submitted to MSCPAC for booking.

(5) The ocean carriers offer space on their vessels to MSCPAC, who book requirements submitted by WAMTMTS to an ocean carrier in accordance with appropriate MSC Shipping Agreements.

(6) The booking is returned to WAMTMTS via teletypewriter.

(7) WAMTMTS releases the booking data to the Container Freight Division at MOTBA.

(8) Upon receipt of the Booking data, the CFD coordinates directly with the ocean carrier to arrange spotting and pickup of containers.

(9) The container is delivered directly to the ocean carrier's container yard.

(10) Depending on the terms of service, either the ocean carrier will effect delivery to the final destination under the MSC Container Agreement or the overseas command will arrange for necessary incountry transportation to the ultimate consignee.

G. CURRENT BOOKING PROCEDURE

The CSS at MOTBA presently books cargo based on a cargo input forecast and the number of measurement tons that will be on hand twenty-one days from now. An offering is made based on: Cargo-on-hand minus cargo already booked plus

the expected amount of cargo receipts from offering to receipt of containers. The CSS computes the previous three weeks' average daily receipts. From this a table is computed which is represented by the graph in Figure 3.

As an example of how the procedure works, one POD will be examined to determine how much space should be booked. Figure 3 illustrates this example. On Julian date 112 there were 474 MT's on the warehouse floor destined for Sattahip, Thailand. The average daily receipts for the previous three weeks (15 days, since Saturdays and Sundays are excluded) for this POD were 138 MT's per day. Space has already been booked on four vessels within the twenty-one day time horizon. The cut off dates for these vessels are days 115, 116, 120 and 128 and have 950, 44, 380 and 760 MT's booked respectively. Between days 112 and 115, 414 MT's will be received based on the past three weeks' daily average receipts. All of the 888 MT's will be stuffed. On day 116, only 44 of the 138 MT's on hand will be stuffed. On day 120 the forecast says there will be 370 MT's on hand to fill space for 380 MT's. Eight days later on day 128 there will be 828 MT's on hand and space booked for 760. By day 134, the day for which the forecast is made, the forecast says there will be 620 MT's on hand. Since the average cube utilization for the POD is 45 MT's, an offering for 14 containers to be available on 134 will be made on day 112.

In summary, the current procedure calls for predicting, based on past cargo receipts and previous bookings, the

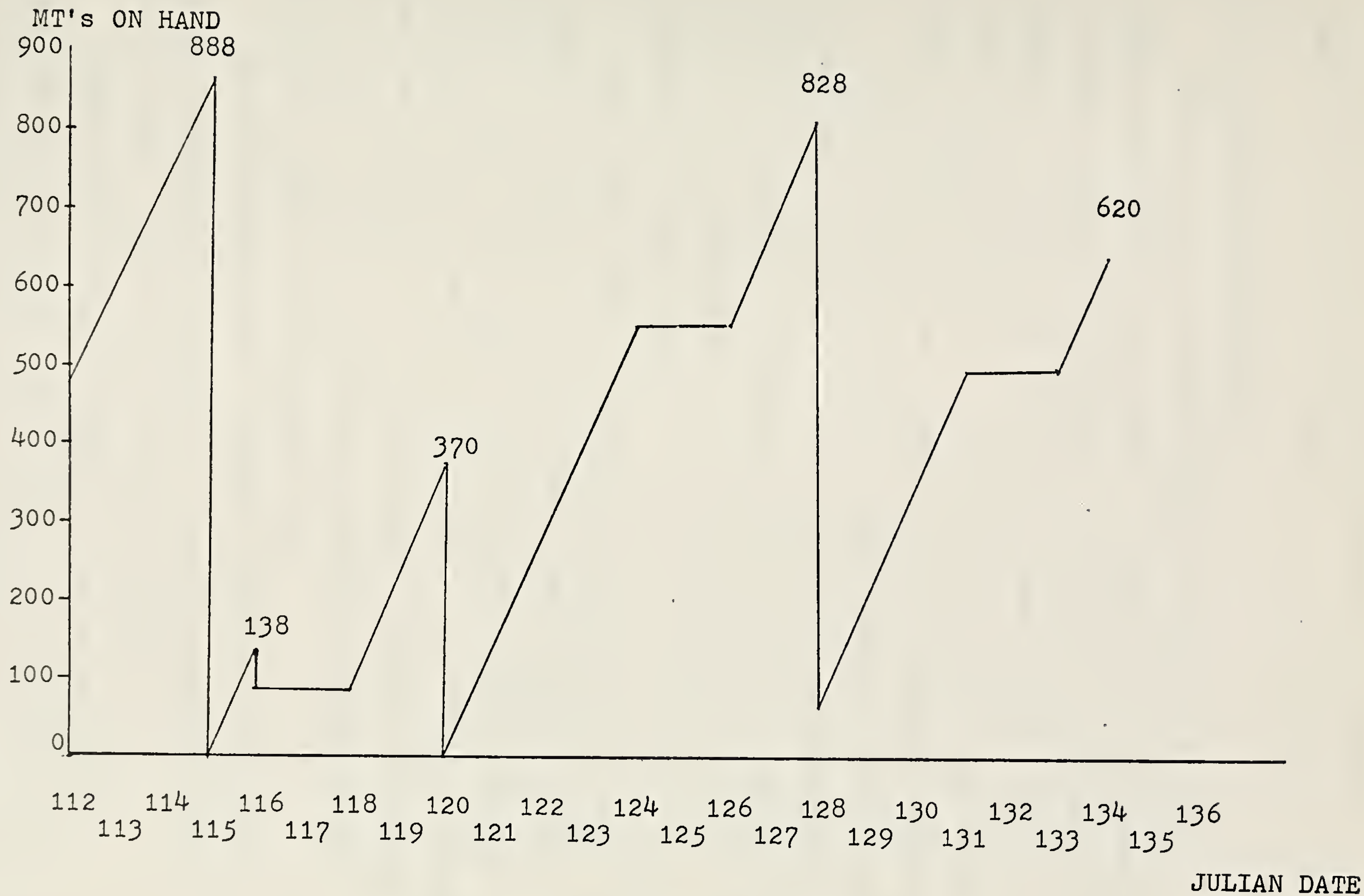


Figure 3: Current Booking Procedure

amount of cargo that will be available for stuffing twenty-one days in the future.

H. OPERATIONAL LIMITATIONS

The Container Stuffing Station is faced with operational limitations that affect the amount and configuration of cargo stuffed in containers. There are also restrictions placed on the way that bookings are made and the CSS's "way of doing business." Following are listed the limitations that have the most impact on the booking procedure.

First-in-first-out (FIFO) - The Contractor is required to maintain a minimum monthly average FIFO performance of 80% for each POD. The purpose is to load the cargo with the oldest receipt date first in order to prevent the generation of aged cargo.

Cargo age - There is no specific limit to how long cargo can remain in the warehouse. Aged cargo is cargo with "undue" time elapsed since receipt. The Contractor is required to investigate cargo which the records indicate has been on hand for over thirty days. Certain categories of cargo do require expeditious handling. These include household goods and pilferable cargo.

Shipment priorities - MILSTAMP required that certain high transportation priorities be moved within specified time frames. This is an exception to FIFO.

Break even cost points (BEP) - This is an economic transportation factor that expresses the percentage of a container's cube that must be utilized if the container is

to be more economical than break bulk shipment. In the past BEP's have been established for each CONUS shipping point and each POD; however, current policies lean toward across the board levels around 50%.

Cube utilization - The Contractor is required to maintain a 75% average monthly cube utilization. Household goods are excluded from this requirement unless mixed with General Cargo.

Cargo compatibility - There are many limitations set forth that limit how various categories of cargo can be mixed. These are for safety reasons and to speed the throughput of cargo. Title 46, Code of Federal Regulations, Part 46 (46 CFR146) governs the transportation of dangerous cargo and their compatibilities. Military Assistance Program cargo cannot be mixed with any other type of cargo. Exchange, subsistence and general cargo are not to be comingled. There are other specific limitations but the above serve to illustrate the type of limitations that the CSS is faced with.

Cancellations - If space booked aboard a carrier is not utilized, the Military Sealift Command, Container Agreement and Rate Guide, RG-8 specifies that the cancellation must be made no later than a "reasonable length of time" prior to the cutoff date. If the cancellation is made after this time and the carrier cannot utilize the space, then the government can be held accountable for the space and must pay as though it were actually utilized. The current WAMTMTS and MOTBA policy is to cancel five days prior to cutoff.

Low cost carrier - The Military Sealift Command's policy in contracting with a carrier is to select the low cost carrier if there is more than one that can provide the required service. This has ramifications in that the low cost carrier may have a sailing schedule that is at a later date than the next highest cost carrier. This has an impact on age and quantity of cargo on hand at the Container Stuffing Station.

III. SYSTEM INTERRELATIONSHIPS AND OPERATIONAL TRADEOFFS

There are two distinct elements which take part in the management of booking activities. The first is the planning element which is synonymous with the administrative element. They provide guidelines which form the framework within which the operator must work. Headquarters, Military Traffic Management and Terminal Service; Western Area, Military Traffic and Terminal Services; Military Ocean Terminal, Bay Area; and the Military Sealift Command all serve as members of the planning element by providing guidelines in the form of directives to the operator concerning such factors as the limitations given in Chapter II, Section H.

The second element is the operational element which consists of the Container Freight Division of MOTBA and the Container Stuffing Station. This is the element actively involved in stuffing and booking containers. Although operating within guidelines established by higher authority, they have enough flexibility to influence performance in that they request space aboard a vessel and stuff containers to utilize that space.

The planners must consider tradeoffs among the response variables. They must consider variations in age, cube utilization, single consignee proportion, quantity of cargo on hand, and the number of tolerable cancellations.

All have cost and effectiveness considerations that must be carefully weighed and measured by the decision maker.

Those making decisions at the planning level must recognize that not only do they have certain tradeoffs to consider, but their actions may force the operational elements into tradeoffs that were not originally considered. For example, when the planner tells the operator that there will be no cancellations, the operator has several alternatives. The operator can book a large number of vans and then in order to avoid cancellations, decrease cube utilization. Cube utilization can be decreased as long as it stays within the planner's 75% cube utilization guidelines. If cube utilization is decreased the single consignee proportion may increase and age may decrease. The operator is forced to make tradeoffs that may not have been intended by the planner.

Theoretically the planner should formulate a general statement of all response variable outputs that can be obtained from all efficient input combinations (note that this is Lancaster's definition of a production function). Mathematically, saying that the response variables are a function of the uncontrollable inputs and controllable inputs simply means that, if some arbitrary values of the inputs are chosen, the value of the output can be determined. Because a given input combination can give a wide range of different outputs, it is necessary to model the system in such a manner as to be able to identify the possible tradeoffs among the performance variables.

A tentative model of the booking policy is given in Figure 4. The interactions and tradeoffs among the listed performance variables must be examined in order to understand the system. Prior to this a few paragraphs are taken to describe how the tradeoffs are generally controlled.

Performance variables are fundamentally controlled by how the system anticipates future events. Cargo inputs are random and vessel schedules are not known precisely; hence the quantity booked can only be for an anticipated amount of cargo on hand for some anticipated time in the future. Even in the case where cargo receipts might be known exactly, there exist unknowns concerning container availability and vessel sailings.

Current policy calls for the CSS to book over a time horizon that extends twenty-one days into the future. This is based primarily on the fact that it takes the system depicted in Chapter II that long to react. There is nothing sacred about the twenty-one day time frame and it could be shortened or lengthened.

Booking requests can vary from a very conservative approach to an optimistic approach. Two extremes are:

(1) Book only the quantity which is on hand the day the booking is made, less that which is already booked.

(2) Book the quantity which is anticipated to be on hand on the expected vessel sailing date, less that which is already booked, plus some set number of extra containers.

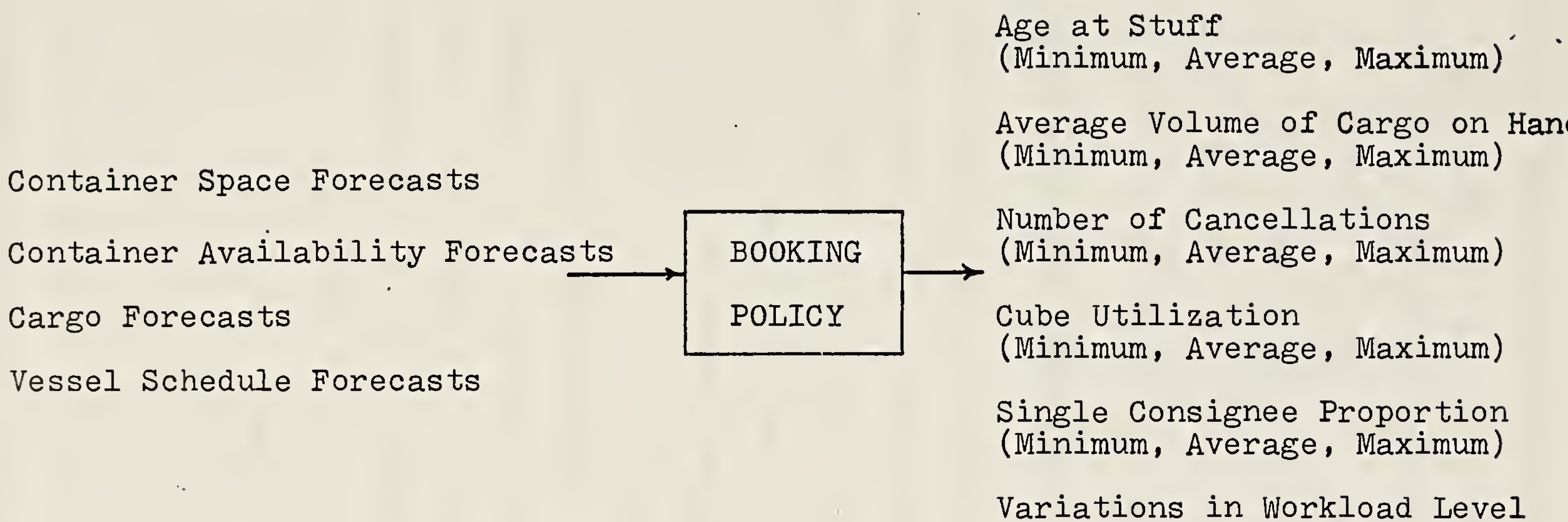


Figure 4: Booking Policy Model (Over Time)

These extremes can be used to identify tradeoffs among the response variables. The most obvious case is in the number of cancellations that the planners are willing to incur. In the first situation, very few, if any, cancellations will occur, but the age at stuff will be high. At the other extreme the cargo will move through the CSS quicker, but more cancellations may exist.

The following sections discuss tradeoffs among performance variables in greater detail.

A. AGE, SINGLE CONSIGNEE PROPORTION, AND CUBE UTILIZATION TRADEOFFS

These three factors have received much attention in the past several years and their tradeoffs are fairly well known. The container tradeoffs, as the tradeoffs among these factors are commonly called, are depicted in Figure 5. The axes of the graph represent average age at stuff and cube utilization. A line on the graph represents an iso-single consignee (SC) proportion. The tradeoffs among the three variables are then fully represented on the two dimension graph. For example, if a starting point of 50% cube utilization and 90% SC is selected, then either single consignee proportion will decrease or age will increase as cube utilization increases.

Since the three factors depend on, among other things, the volume of cargo throughputs, it necessarily follows that as cargo input decrease to any one consignee (assuming break bulk shipping is a less viable alternative to

IF:	THEN:	OR:
CUBE UTILIZATION INCREASES	SINGLE CONSIGNEE DECREASES	TIME IN TERMINAL INCREASES
CUBE UTILIZATION DECREASES	SINGLE CONSIGNEE INCREASES	TIME IN TERMINAL DECREASES
SINGLE CONSIGNEE INCREASES	TIME IN TERMINAL INCREASES	CUBE UTILIZATION DECREASES
SINGLE CONSIGNEE DECREASES	TIME IN TERMINAL DECREASES	CUBE UTILIZATION INCREASES
TIME IN TERMINAL INCREASES	CUBE UTILIZATION INCREASES	SINGLE CONSIGNEE INCREASES
TIME IN TERMINAL DECREASES	CUBE UTILIZATION DECREASES	SINGLE CONSIGNEE DECREASES

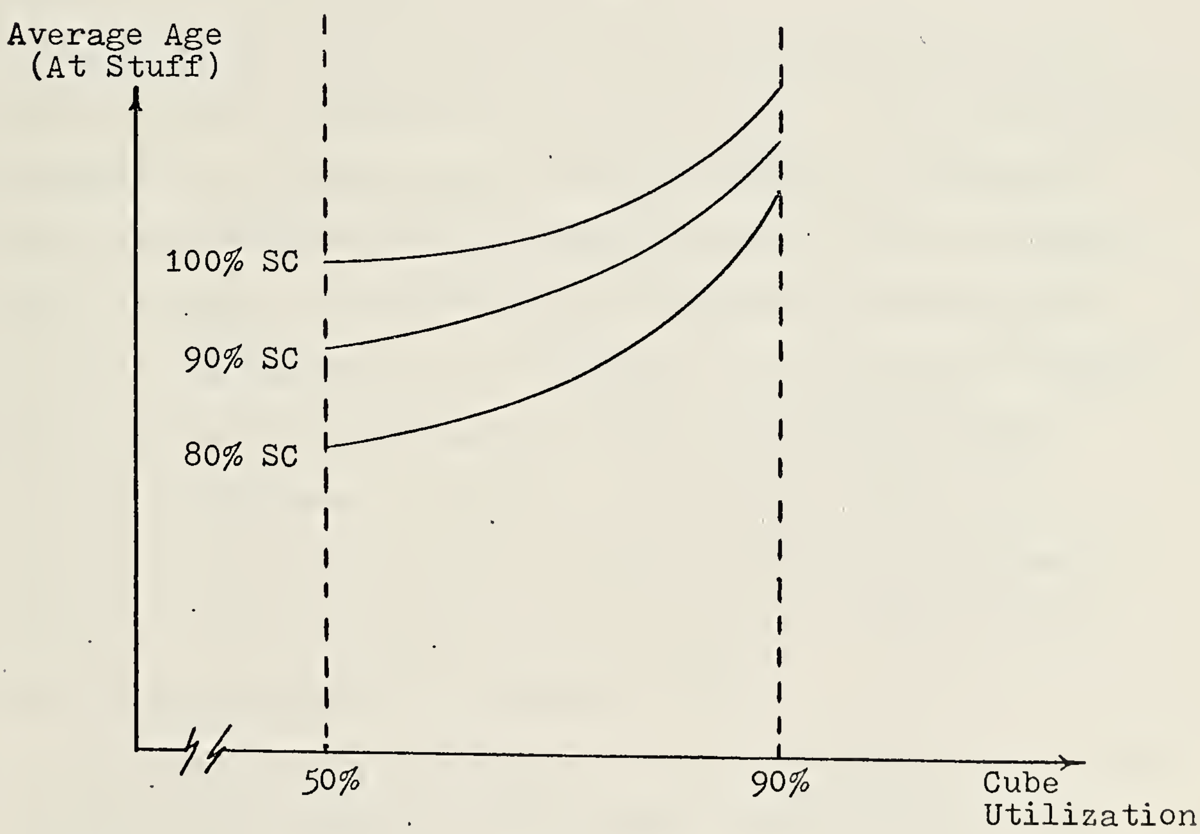


Figure 5: The Container Tradeoff

containerization), cargo will either become aged, shipped at a relatively low container cube, or require more consolidation or mixing.

The Container Stuffing Station does not directly control the volume of cargo coming into the station. However, it does control, within the prescribed limitations listed in Chapter II, the manner in which cargo is stuffed into containers; hence it has control over the tangible and intangible costs associated with each factor. The costs associated with age are primarily the costs that the consignor has to incur in not having the material or in having to maintain higher inventory levels in order to account for the longer lead times.

The costs associated with single consignee proportion are primarily handling costs at the POD. If a container is stuffed with cargo going to one and only one consignee, then the container is delivered directly to that consignee and unstuffed. If a container is stuffed with cargo for several consignees, it is delivered to a break bulk station where it is unstuffed and the cargo is then delivered to the designated consignees. If mixing occurs, one of the primary advantages of containerization is defeated, which is the minimization of intermediate cargo handling and related damage and pilferage costs.

Cube utilization influences ocean carrying costs. The ocean carrier transportation charge is based on the container and not on the volume or weight of the cargo inside

it. It therefore costs just as much to move a half full container as a full container. It is obvious then that in order to minimize the ocean transportation cost per unit volume of moving cargo it is necessary to maximize cube utilization.

If cube utilization is too low, then it is more economical to ship the cargo break bulk. The break even cost points explained in Chapter I are the percentage of container cube utilization that are necessary to make containers as economical as break bulk shipments. It should be noted, however, that break bulk vessel schedules are more erratic and less frequent. For certain cargos which are shipped break bulk, this may result in an inordinate amount of delay.

One conceptual problem related to these factors is to find the tradeoff between single consignee proportion and cube utilization which minimizes the relevant costs while controlling the cargo delay times within acceptable limitations. In terms of transportation costs, Professor J.P. Hynes of the Department of Operations Research and Administrative Sciences at the U.S. Naval Post Graduate School, stated in a technical paper entitled "Container Stuffing Policies and Transportation Cost Minimization" that:

> ...maximum attainable volume utilization must be kept foremost in mind when it comes to contemporary military ocean container cargo transport cost minimization for the stuffing station under examination.

From a transportation cost standpoint he was saying that single consignee proportion should not be emphasized. The planner must keep this in mind while at the same time weighing the other costs associated with age, single consignee proportion and cube utilization.

B. AGE VS. CANCELLATIONS

There is a relationship between the number of cancellations and the average age of cargo at time of stuff. Other things being equal, average age increases as cancellations decrease. The curve, for a given POD over time, will look something like that in Figure 6. It is obvious that booking only that cargo which is on the floor less that which is already booked will result in few, if any, cancellations. At the other extreme, overbooking (booking more space than there is cargo available to fill it) will result in decreased age and an increased number of cancellations.

The minimum time in terminal that is ideally possible is equal to one half the average time between consecutive sailings. The age for other points on the curve will depend on the rate of arrival of cargo at the Container Stuffing Station.

Utilizing a simulation model developed by Professor J.P. Hynes, data was generated to determine if the relationship between average age and the number of cancellations did behave as indicated in Figure 6. (See Appendix A for details.) The simulation was used to

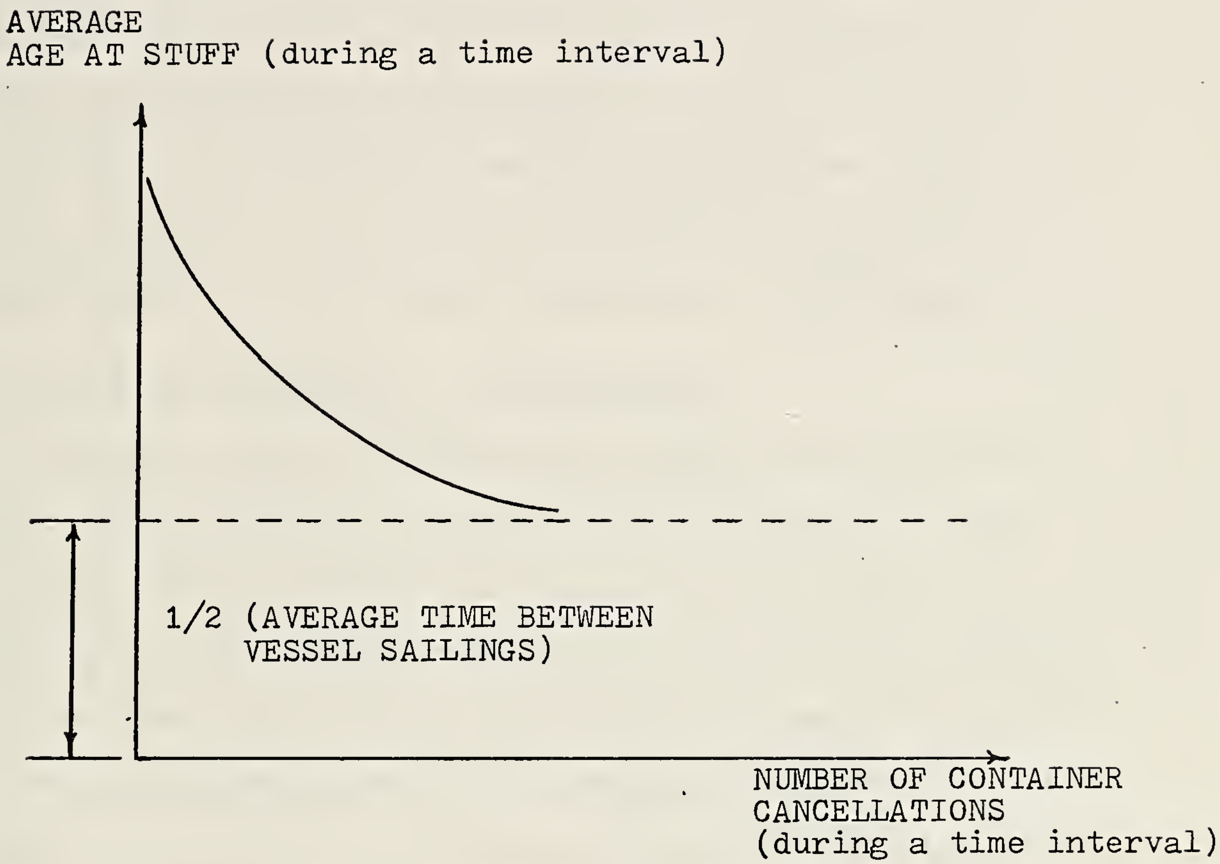


Figure 6: Age-Cancellation Tradeoff
(For a POD over time)

simulate alternative booking procedures. It was found that the curve indeed did look similar to that in Figure 6.

A policy of cancelling containers five days prior to cutoff or having zero cancellations may not be the best policy. In some cases the age of the cargo may be more important than the cost of cancellations. Cargo may be delayed to the point where the costs of holding it or the costs incurred by the consignor in not having the material may be greater than the cancellation costs. This is the nature of the cost tradeoff that must be considered in establishing cancellation limitations.

C. CUBE UTILIZATION VS. CANCELLATIONS

There is also a relationship between the number of cancellations and the average cube utilization. This relationship, over time for a given POD, is shown in Figure 7. The average cube utilization can vary between one hundred percent and the seventy-five percent that the Container Stuffing Station is required to maintain. It should be noted that one hundred percent cube utilization will never be reached because of cargo configurations, compatibility restrictions and the various other factors that must be considered when stuffing a container. An upper limit of something less than one hundred percent will actually be experienced.

If the policy is to book only that cargo which is on the floor less that already booked, then typically there will be more cargo than space and cube utilization will

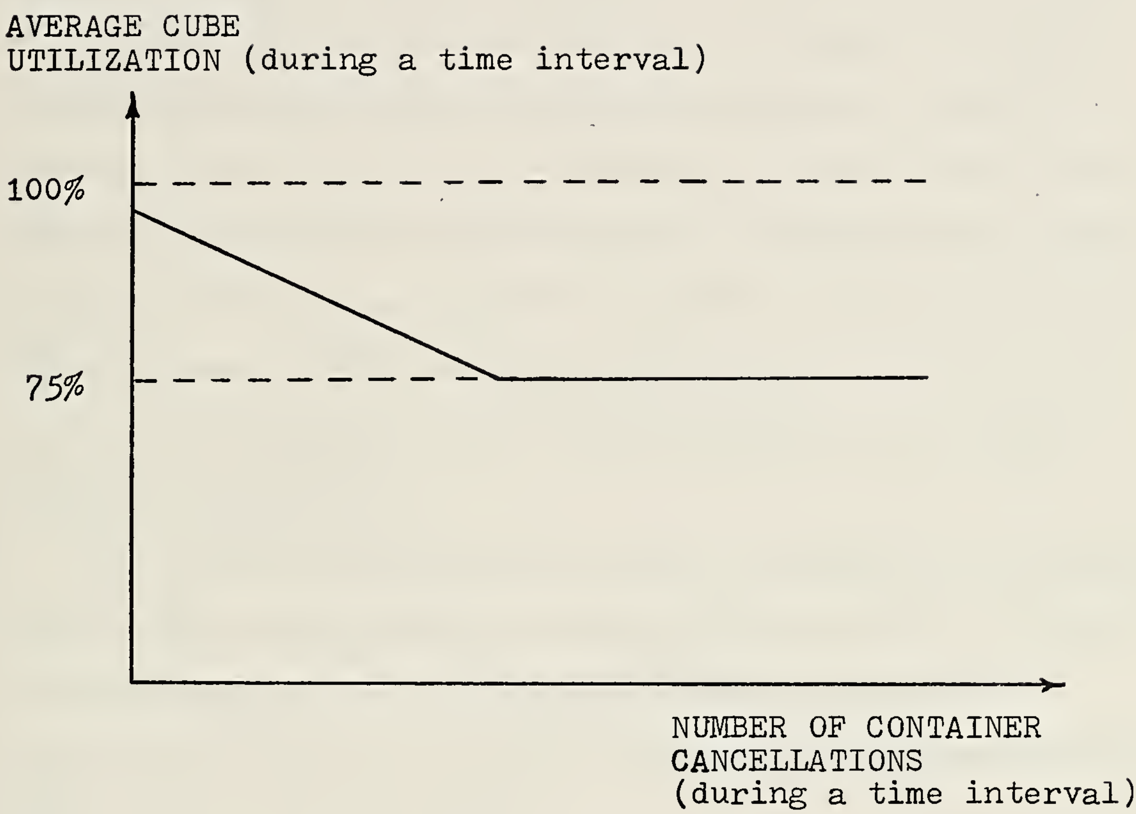


Figure 7: Cube Utilization-Cancellation Tradeoff
(For a POD over time)

increase. On the other hand if there is always more space than cargo, cube utilization will tend to decrease and cancellations will occur. Cube utilization will decrease because of the attempt to spread cargo over as many containers as possible in order to avoid cancellations. If there is too much space booked cancellations will occur despite decreased cube utilization. The slope of the line in Figure 7 will depend on the volume of cargo available for stuff and the single consignee proportion. As previously pointed out, the relationship between cube utilization and single consignee proportion is such that as single proportion increases, age may increase or cube utilization may decrease. If it is assumed that age is held constant, then cube utilization will vary depending on the single consignee proportion.

The costs associated with cube utilization, as explained previously, are primarily ocean carrying costs. The costs of cancellations must be weighed against the costs associated with the increased cost per unit volume resulting from lower cube utilization.

The SIMCON simulation of Professor Hynes was utilized to compare cube utilization and the number of cancellations. Cube utilization decreased very slightly for large increases in the number of cancellations. From the data (See Appendix A), it is apparent that major reductions in cube utilization do not occur with increasing cancellations.

D. AGE VS. QUANTITY ON HAND

The average quantity of cargo on hand (congestion) can be indicative of shipment aging when first-in-first-out (FIFO) procedures are used. The Container Stuffing Station attempts to operate on a policy of FIFO. That is, cargo which arrives first is hopefully stuffed first in order to prevent aging. Again, if in an ideal case, cargo inputs are known exactly, vessel sailing dates are known, containers and container space are available, there would be few problems. However, variances and shortages do exist and cargo accumulates. Also there are single consignee and cargo compatibility considerations and FIFO cannot always be followed.

It is sometimes justifiable to express concern over a large buildup. This should not be allowed to imply that a lack of congestion is indicative that everything is operating smoothly. That small quantity may have been in the warehouse for an extended period of time.

Holding all other factors constant, shipment age at time of stuff versus the average quantity on hand (over time) looks like the curve shown in Figure 8. Changing any of the other factors will change the shape of this curve.

It is important to realize that even a small amount of cargo delayed for an extended period of time may result in increased costs for both the CSS and the consignor. The CSS will be faced with higher holding costs for the

(All other factors held constant)

Figure 8: Age-Quantity on Hand Tradeoff
(For a POD over time)

specific aged shipment and the consignor may be faced with higher out-of-stock costs. If delays to a particular POD are always large, the consignors at that POD may be forced to maintain high inventory levels with the associated handling and carrying costs. To the system as a whole, it may be more cost effective to move the cargo at a lower cube utilization in order to reduce age.

E. WORK LOADS AND CHANGES IN WORK LOADS

The consequences of variations in the work load are difficult to quantify; however, it is possible to point out what may occur when peaks and valleys in the work load happen.

When the work load is low, the employees of the Container Stuffing Station have more time to perform their duties. Generally when he is not rushed, a worker performs better and has time to pay more attention to detail. On the other hand if there is a big push to stuff a large number of containers to meet a cutoff date, several areas of the container stuffing operation suffer. There is less attention paid to how a container is stuffed. Cube utilization will most likely decrease because not much attention is paid to how the various pieces of cargo will fit in the container.

If there is more time, more attention can be given to the configuration of the cargo and how it fits together in a container. Also associated with poor container stuffing methods is the increased possibility of damage to the

cargo. This would result from poor blocking and bracing methods being used in the rush to meet a cutoff date.

Other areas that would show decreased performance are the first-in-first-out proportion and the number of documentation errors.

Unless there is a definite trend in the level of the work load over time, peaks and valleys do not generally result in the Container Stuffing Station being placed in the position of having to hire or fire employees. At peak times, overtime is utilized, while at slack times, other tasks are found for the employees.

If cargo inputs are known exactly, vessel sailing dates are known, and containers and container space are available, then cargo could be booked to avoid variations in the work load. Since the government has little control over vessel schedules, it is impossible to entirely prevent peaks in the work load. If two large POD's have vessel cutoff dates that coincide, then the Container Stuffing Station has to react by letting some other POD's cargo wait or use overtime to accomplish the work.

If containers were available far enough in advance, then the work load could be spread over a longer time period. On slack days, containers for POD's with large quantities of cargo could be stuffed and then set aside until the cutoff date.

IV. PROBLEM APPROACHES

Now that the nature of booking has been examined, it is logical to ask what approaches might be taken to formulate booking policies and procedures. Establishing a technique that can be readily utilized by the operator is not an easy task nor is it the intent of this thesis; rather, the intention is to provide a general framework for attacking problems.

A. PERFORMANCE UTILITY

The planner is motivated to select booking policies which achieve desired objectives, based on a general statement of all outputs that can be obtained from all efficient input combinations as discussed in Chapter III. These objectives include actual levels of the performance variables as well as the costs associated with the performance variables. This utility function can be characterized by the following equation:

maximize: $x = f(t, v, u, c, q)$

where: x = measure of effectiveness
t = age
v = single consignee proportion
u = cube utilization
c = number of container cancellations
q = average quantity cargo on hand

One way of formulating this utility function is to characterize each function of its relevant costs. Typical

costs that are associated with the container transportation system are:

(1) Container stuffing costs

(2) Inventory carrying costs

(3) Cargo handling costs

(4) Inland transportation costs

(5) Ocean transportation costs

(6) Cancellation costs

Each variable has associated with it different sets of the above costs and in different proportions. The planner must decide on the priority of the performance variables and weight these accordingly when measuring overall performance. The utility function is then expressed in terms of the costs associated with the performance variables. In general, as costs increase, utility decreases.

The concept of utility carries with it the idea of preferences. Increased utility implies increased preference. For the decision maker or planner, lower costs are preferred to high costs, but he must also decide which of the performance variables or which set of the performance variables is most preferred. In general, utility increases with increasing cube utilization, increasing single consignee proportion, decreasing age, decreasing average quantity of cargo on hand, and decreasing container cancellations. It is when the decision maker wants to maximize the utility of all the performance variables that he must consider tradeoffs.

One area where utility can be readily identified is the age and quantity on hand tradeoff. The tradeoff breaks down to a classic economic analysis of utility. The conceptual tradeoffs are shown in Figure 9. The curved lines on the graph depict levels of utility or hypothetical indifference curves along which a decision maker is indifferent to age and quantity on hand. The set of indifference curves describe the utility function of the decision maker. This gives the relative preferences between any two sets of alternatives. Ideally, but not realistically, the best position to be in is at the origin. As one moves away from the origin, utility decreases. The absolute value of the slope of an indifference curve is equal to the marginal rate of substitution; or that measure of age that one is willing to trade for quantity on hand and remain at a constant level of utility.

In the economic sense, a utility function is defined as a real valued function used to model choice and, as in the case of most utility functions, defining that real valued function is extremely difficult. The issue is to point out that tradeoffs do exist between age and the quantity of cargo on the warehouse floor.

While a decision maker at the policy level is interested in overall system utility and performance, a decision maker at the operating level has an entirely different utility framework and is only concerned with his operation. For example, at a stuffing station, one would want to be able

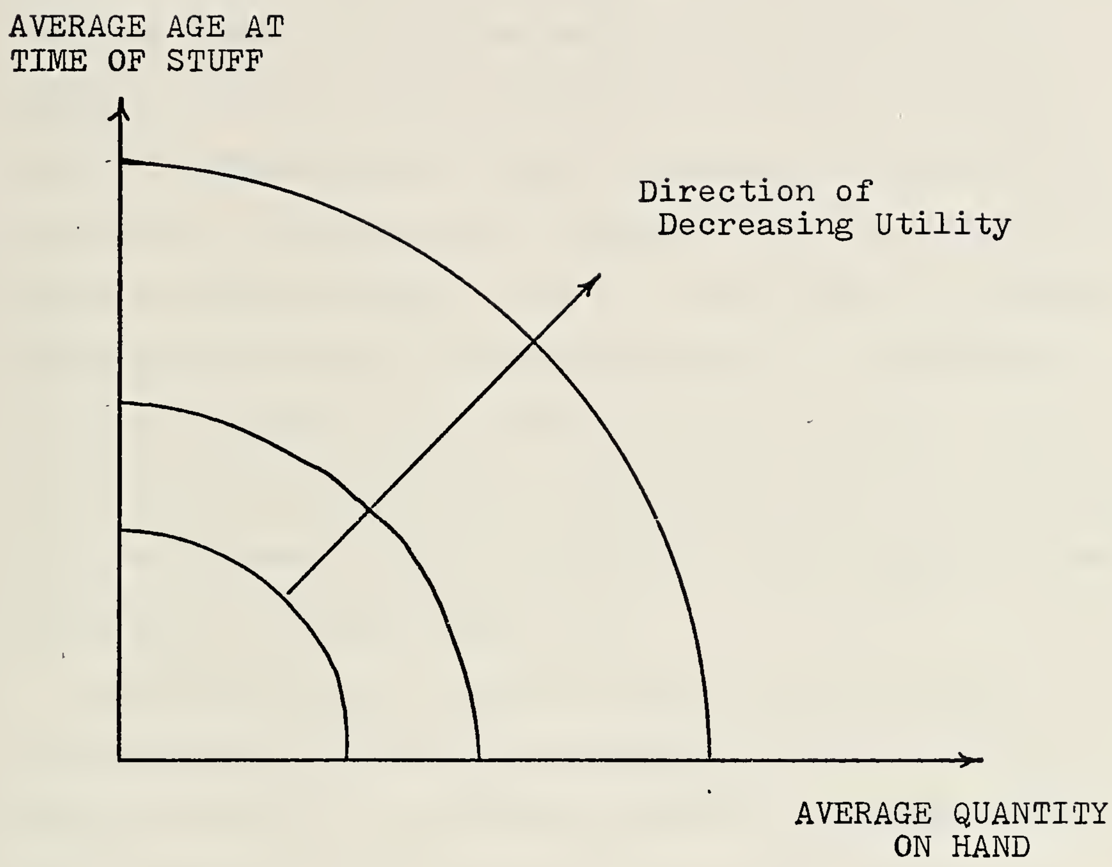


Figure 9: Utility of Age and Quantity on Hand

to look at the quantity of cargo on hand and expected receipts and have an index of performance for some particular aspect of the operation. For instance, with an index which measures the performance of the booking operation, the Container Stuffing Station could tell how far ahead or behind in bookings they are. This index could be used to determine what policy to follow if certain situations arise or initiate corrective action when performance is low. As an example, a baseline of 100 could be established to identify the case where the CSS was making bookings in such a manner that all objectives were being met. As age increased or quantities on hand increased, the index would be increased. As cancellations increased or other indications of overbooking, such as decreased cube utilization, became apparent, the index would decrease below 100.

Cargo adjustment factors could be used as inputs to the performance index. An adjustment factor would be a weighting factor to establish minimum or maximum effective container volume required for a given commodity. The prime example would be for household goods. Because of their peculiar configuration, special size and shape considerations must be addressed. There are other commodities where such an adjustment factor could be established.

B. IMPLEMENTATION TECHNIQUES

The following are possible methods of arriving at measures of booking performance and defining a suitable production function as discussed in Chapter III. The techniques can be used to analyze the relationships of the attainable levels of utility with the production function. Also given are some of the difficulties and drawbacks associated with each technique.

1. Computer Simulation

In a simulation model, one would select (formulate) possible booking policies, simulate them, evaluate their characteristics, and select the one which best meets the desired objectives. Using the utility concepts discussed previously, the "most desirable" set of performance variables can be identified. What one wants in terms of age, single consignee proportion, cube utilization and cancellations would be considered.

An approach in using a simulation is to generate a limited amount of data, reduce the data to equation form, identify optimal regions of operation, and then use the results to interpolate back to specific optimal booking policies.

One possible simulation model which could be used is the SIMCON model developed by Professor J.P.Hynes. His model replicates the major factors influencing tide-water container stuffing stations, to include variations in vessel departures, shipment inputs, booking containers aboard vessels, and stuffing restrictions.

By utilizing the booking procedure in Professor Hynes' simulation model and varying the various input parameters, one could generate sets of data corresponding to various identifiable policies and select the one that best fits desired goals or specific situations.

2. Queueing Models

If the arrival rate of cargo at the Container Stuffing Station and the service rate (rate at which cargo is stuffed and lifted) were known, then the process could be characterized by a queueing model. Cargo arrives at and leaves the CSS in discrete quantities. Figure 10 depicts these discrete arrivals and departures, the cumulative space requirements, and cumulative cargo stuffed. If N_t equals the cumulative amount of cargo arriving by time t and M_t equals the cumulative amount of cargo leaving by time t, then the area between the two curves will give the total measurement tons of unit time delay. The delay of the $i^{\underline{th}}$ measurement ton is given by d_i and q_t is the volume in measurement tons of cargo in the warehouse at time t.

If the actual or expected arrival rate is known, then the forecasted or anticipated cargo delay can be used as a measure of performance. The service rate or booking rate can also be determined if the arrival of cargo, vessels, and containers is known and delay restrictions are specified.

The whole process here depends on characterizing ship arrivals, container availability and cargo inputs

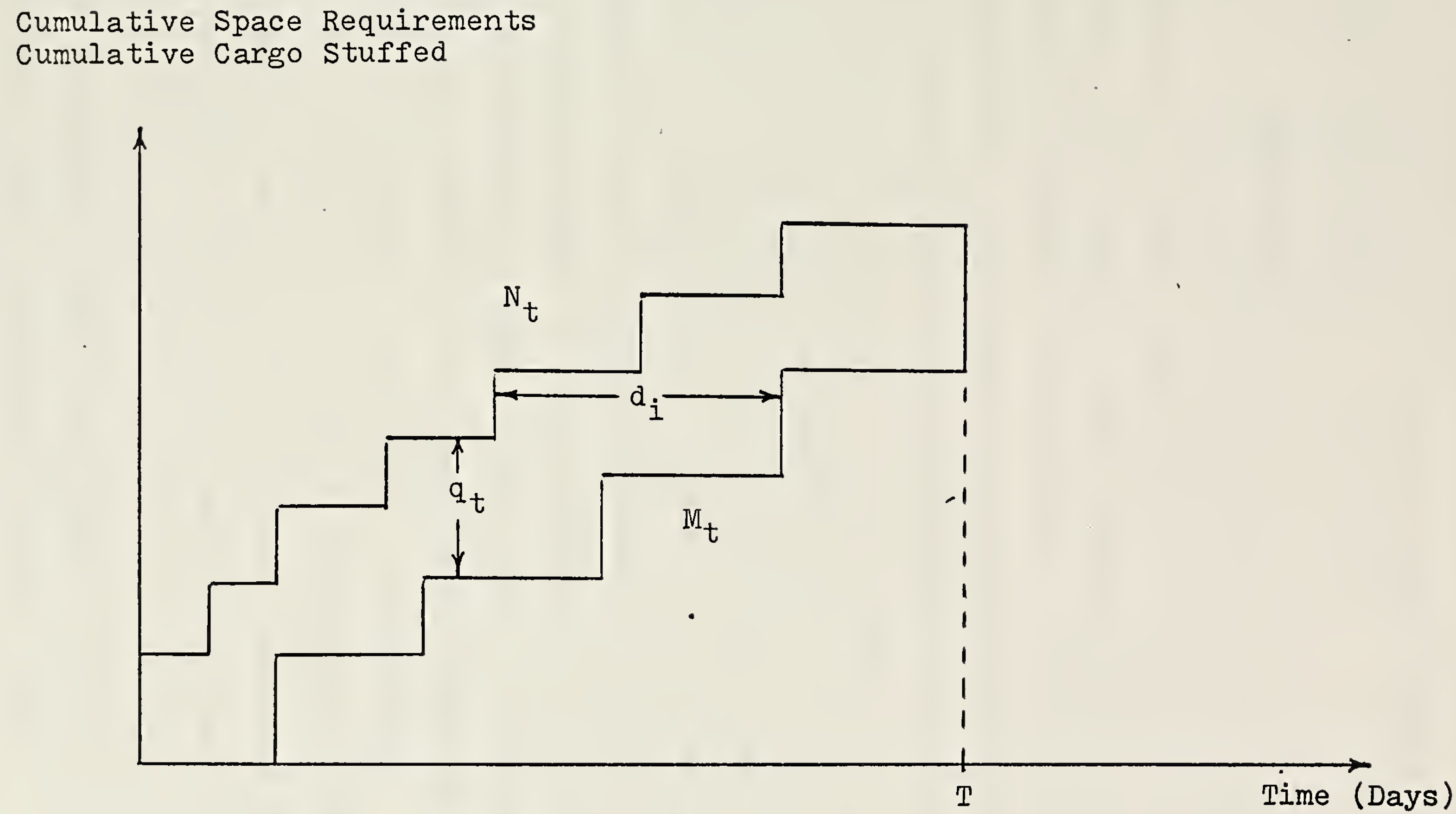


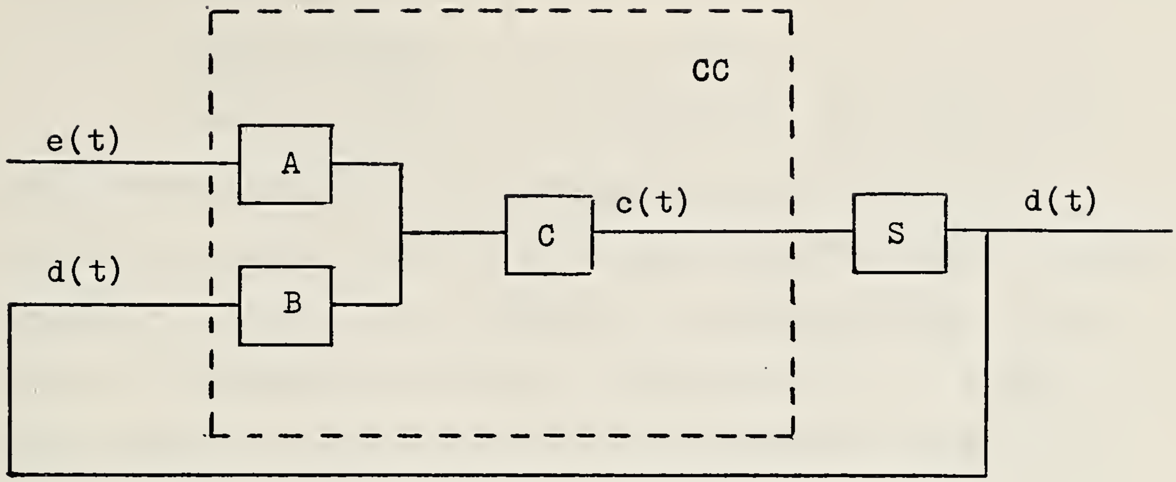
Figure 10: Queueing Model

as random processes. It is necessary to point out that cargo arrivals and departures may not be homogeneous Poisson Processes since the number of events occurring in any interval of time does not depend only on the length of that time interval. (8, 115-118)

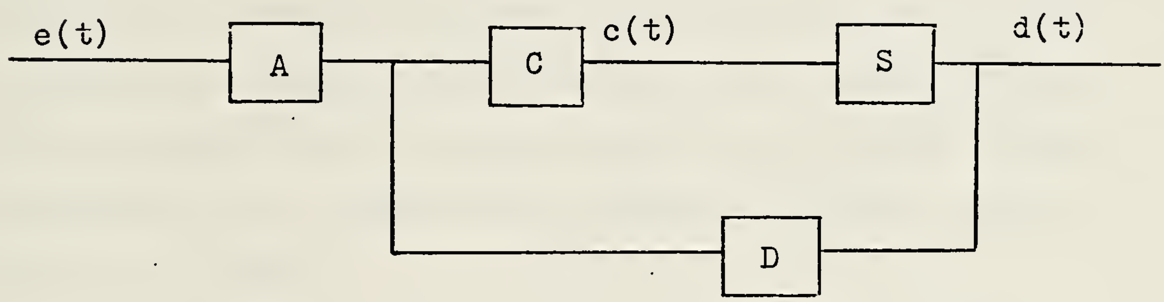
3. Control Theory

From a deterministic standpoint, the booking problem is a classic application of control theory. Figure 11(a) shows the entire system and Figure 11(b) shows the functional representation of the system. Cargo inputs to the system are represented by e(t) and d(t) represents the output of system S, i.e., bookings. The system CC is used to calculate control, c(t), such that d(t) is as close as possible to e(t). An anticipative system, A, could include such factors as a cargo adjustment factor; a weighting factor used to indicate minimum or maximum container volume required for a given commodity. The feedback system is represented by B, and C represents the compensation system. Notice that A is in series with the other systems and hence the total system can be studied without anticipative componets. (7, 198-199)

The problem in using a servomechanism model is in determining what the recursive relationship is between cargo inputs, cargo on hand, and booking quantities. There is no simple relationship which connects cargo inputs with the factors affecting bookings (container availability, container space, and vessel sailings) because of the



(a)



(b)

Figure 11: Servomechanism Model

tradeoffs and variations among the response variables as previously mentioned.

4. Dispatch Model

This is a natural extension of an inventory model. The booking problem is the opposite of most inventory models and can be dealt with using a dispatch model. In an inventory system, the problem is to maintain a stock level based on demands or decreases in that level. In a dispatch system, the problem is to decrease the stock level based on inputs that increase the level.

A dispatching policy can be described as a pair of quantities, L equal to the "target" load or cube utilization factor, and H equal to a minimum holding time. The policy is that a shipment is held until either there is enough co-containerizable cargo to fill the fraction L of a container, which is then moved to the carrier's yard (dispatched), or a time H has elapsed, whichever occurs first. (8, 64-67)

To model this system it is necessary to assume some arrival rate of cargo at the Container Stuffing Station and some distribution for the size and type of arriving cargo. With this information and a distribution for delays, a reasonable approximation of how cargo moves through a CSS can be modeled. A dispatch model of this type also assumes that containers are always available for stuffing. In reality, containers are not always available when needed and the CSS must often wait until they do become available.

C. INTERMEDIATE OPERATIONAL TECHNIQUES

The preceding models are recommended methods of approaching the container booking problem over the long run at the policy level. A procedure for use at the operating level is recommended here to forecast the position of the Container Stuffing Station in regard to bookings. An index of the position of the CSS should take into consideration both the quantity of cargo on hand and the expected age of that cargo when lifted. The procedure detailed here involves the use of two indices for a given POD, one for age and one for the quantity of cargo on hand.

The present policy of treating all cargo received during a given calendar week as equivalent in terms of receipt date will be adhered to. On any given day the average age of the cargo on hand for a POD can be determined. The important age, however, is the anticipated or forecasted age of the cargo at time of stuff. Cargo is more or less moved on a first-in-first-out basis; therefore, cargo currently on hand can be identified to a vessel on which space is booked. The age at time of lift of that cargo already booked can be determined by adding the number of days until it is lifted to its present age. The age of the cargo that is not currently booked can be determined by adding its present age to the time horizon over which bookings are being made. (This will probably underestimate the age at lift because vessels will not be available at exactly the end of the time horizon.) The

age of expected cargo receipts can be determined by subtracting the number of days into the time horizon which it is expected to be received from the number of days in the time horizon. If any of these ages are greater than specified limits, then there is reason for concern.

One method of determining a limit is to use a constant times the average time between consecutive lifts for a given POD. This time will be different for different POD's and so should the constant multiplier be different. For instance, if the average time between consecutive lifts is three days for one POD and twenty days for another POD, a multiplier of one may be appropriate for the latter case, while a multiplier as high as five may be okay for the former.

The quantity on hand at time of stuff or just prior to stuff can also be forecasted for a given POD. Note that it is important to look at the quantity on hand at time of stuff. If there is one thousand measurement tons on hand today, but it is all booked for lift in three days, there is little cause for concern if the age is within limits. What the limits are for quantity on hand will also be different for each POD. The recommended limit is a constant times the average volume in measurement tons per lift.

If the age at time of lift is greater than a constant times the average time between consecutive lifts and/or the quantity on hand at time of stuff is greater than a

constant times the average volume in measurement tons per lift, then the Container Stuffing Station should take a look at their current operation because cargo is becoming overaged or accumulating.

Exact details of how these indices should be computed are not detailed here. A procedure should be established by the CSS that allows for the indices to be computed using normal work statistics and reports.

V. CONCLUSION

By recognizing and analyzing the tradeoffs among congestion, cancellations, shipment delay, single consignee proportion, container cube utilization and work smoothing, the CSS can establish policy and procedures that produce operational performances which better meet the needs of the transportation system. By optimizing these factors, the Container Stuffing Station provides better service to its customers and is more cost effective in its operation.

The Container Freight Division of the Military Ocean Terminal, Bay Area, has a booking system; but in general, there is some ambiguity as to how well it is performing. Their only indicator is the amount of cargo on the warehouse floor. When there is a large quantity, it appears they are in a bad position; and when there is a small quantity, they appear to be in a good position. This may not really reflect ultimate performance because cargo age is also a factor. By observing not only the quantity of cargo on hand at time of lift but also the average age of that cargo at time of lift, the CSS can better ascertain their position with regard to booking cargo for container vessels.

The approach which was recommended to develop "optimal policies," was to establish a utility function, then using

various implementation techniques, develop production functions to analyze the relationships among performance variables and attainable levels of utility. These techniques included computer simulation, queueing models, control theory and dispatch models.

In assessing some simple tradeoffs among alternative booking procedures, it was shown that allowing some cancellations to occur does result in a significant reduction in age.

APPENDIX A. SIMULATION DATA

The goal of this SIMCON simulation was to assess some simple tradeoffs among alternative booking procedures.

Generally speaking, the booking algorithm in the simulation examines a list of vessel arrivals extending over a three week time horizon. Then, taking into account on-hand POD inventories, expected volume inputs, and historical volume utilization factors, the expected number of stuffed containers that can be loaded on each vessel upon its arrival is forecasted. A comparison of needs with existing bookings determines whether or not additional bookings are necessary.

Calculation of space requirements is made by taking the on-hand cargo volume for the POD in question, adding to that the expected cargo volume which will arrive in time to be stuffed into containers and lifted aboard the vessel, and subtracting from that the total volume of cargo already booked aboard vessels destined for the POD. The routine then determines the number of containers necessary to meet these requirements, taking into account recent volume utilization factors for the POD and type of container in question.

The parameter CFAF, indexed by POD, is an adjustment factor used in calculating expected cargo receipt volumes when estimating booking requirements. If CFAF equals one, then expected receipts will be the daily volume forecast

times the effective number of days before the vessel's arrival. If CFAF equals 0.5, then expected receipts would be half the above, etc.

Ten simulations of 180 days in length were run varying CFAF from zero to two and one half. The factors utilized were 0.00, 0.25, 0.50, 0.75, 1.00, 1.25, 1.50, 1.75, 2.00, and 2.50. The tables and graphs at the end of the Appendix represent the data generated for the six largest POD's in terms of the total number of shipments made to that POD.

The tables include the following data elements:

CFAF - the cargo forecast adjustment factor.

MEAN AGE - the average age of cargo at time of stuff in days.

CUM. PERCENTAGE CHANGE - the cumulative percentage change in mean age between simulation runs with CFAF equal to 0.25 taken as the vase.

CUBE UTIL - the average percentage of container space displaced by cargo.

CHANGE - the absolute change in cube utilization between simulation runs with CFAF equal 0.25 taken as the base.

NO. CANCEL - the total number of container cancellations for the given POD over a 180 day period of simulation.

NO. LIFTS - the total number of container lifts for the given POD over the 180 day period of the simulation.

NO. CAN. PER LIFT - the average number of cancellations per lift of the 180 day period of the simulation obtained by dividing the total number of cancellations by the total number of lifts.

The graphs depict for a POD the average age at stuff in days versus the number of cancellations per lift. Each point plotted on the graph is the data element for a simulation run with a specific value for CFAF.

Note that the data point for CFAF equal to zero did not fit the curve as described in Chapter III. This is due to space and container availability parameters used in the simulation, along with a paradoxical phenomenon which occurred in these simulations. When CFAF is greater than zero, vessels are booked throughout the 21 day time horizon because cargo inputs are anticipated over the period. In the simulation, this locks the stuffing station in to container commitments which, at a later date, may prevent the booking of on-hand cargo to vessels arriving earlier than those vessels that already have the bookings. When CFAF is equal to zero, however, these commitments do not occur, and bookings will always be made on the earliest arriving vessel. The paradox arises here in that cargo ages are higher when anticipating cargo arrivals on a small scale (e.g. CFAF=.25), than they are when not anticipating cargo arrivals at all (e.g. CFAF=0). Nevertheless, cargo age is minimized over all by anticipating cargo on a large scale (e.g. CFAF=2.5). It should be emphasized here that this paradox will not be present in simulations where limited container space and delay factors eliminate the possibility of short lead time cargo bookings on vessels arriving in the immediate future.

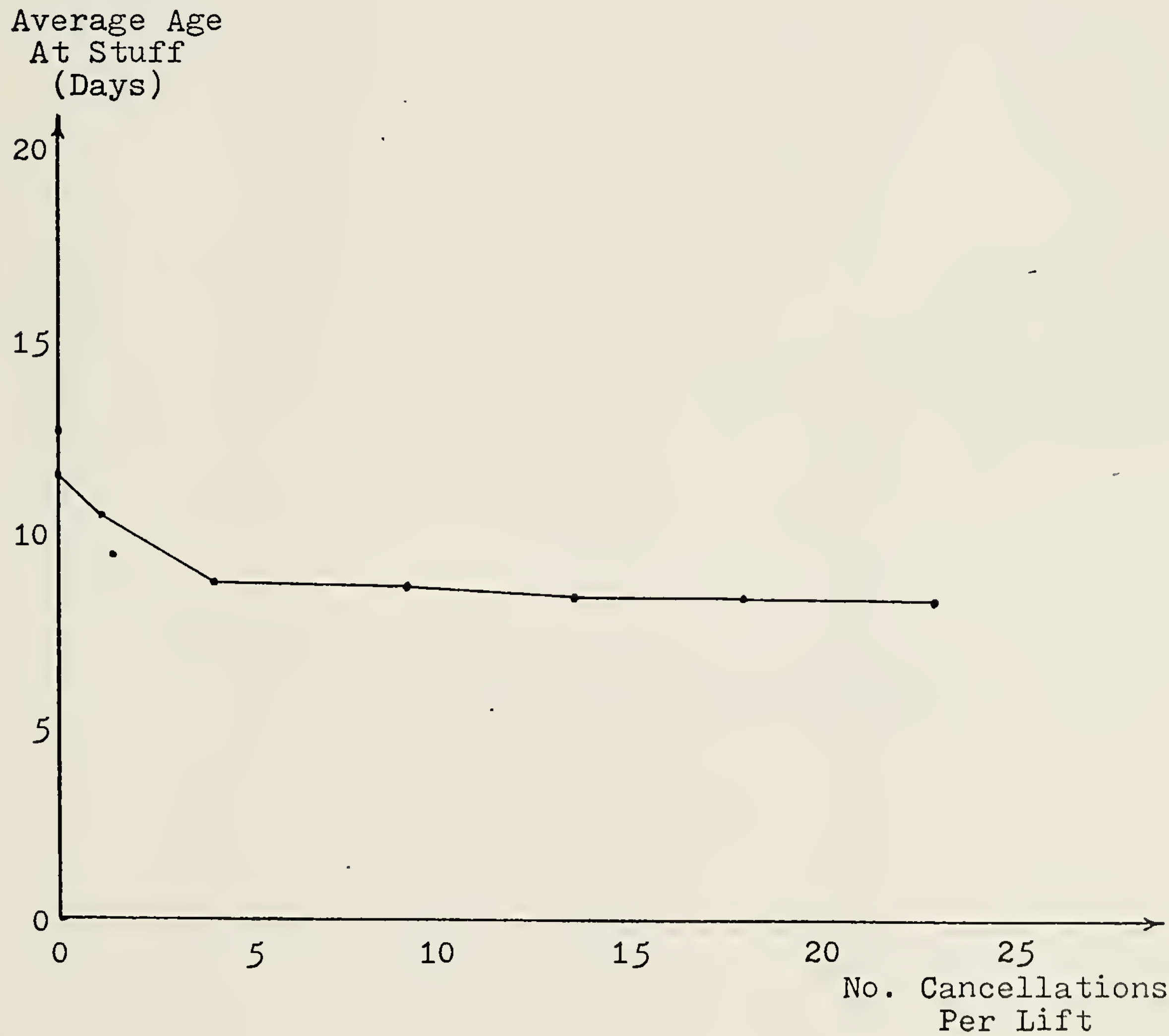
Disregarding the data point for a CFAF equal to zero, a minimum age was reached quite rapidly; but that age was more nearly equal to the average time between consecutive vessel sailings and not one half the average time between consecutive vessel sailings. This is partially due to cargo compatibility restrictions, minimum load requirements, and booking delays inherent in the system.

An important fact that the simulation showed is that the amount to be booked and the tradeoffs vary from POD to POD and that each POD should be analyzed separately.

Changes in cube utilization ranged from an increase of 0.4% to a decrease of 2.6%. Only one POD in the simulation showed an increase in cube utilization with decreased age. This was regarded as a random error; different simulation runs would produce different results.

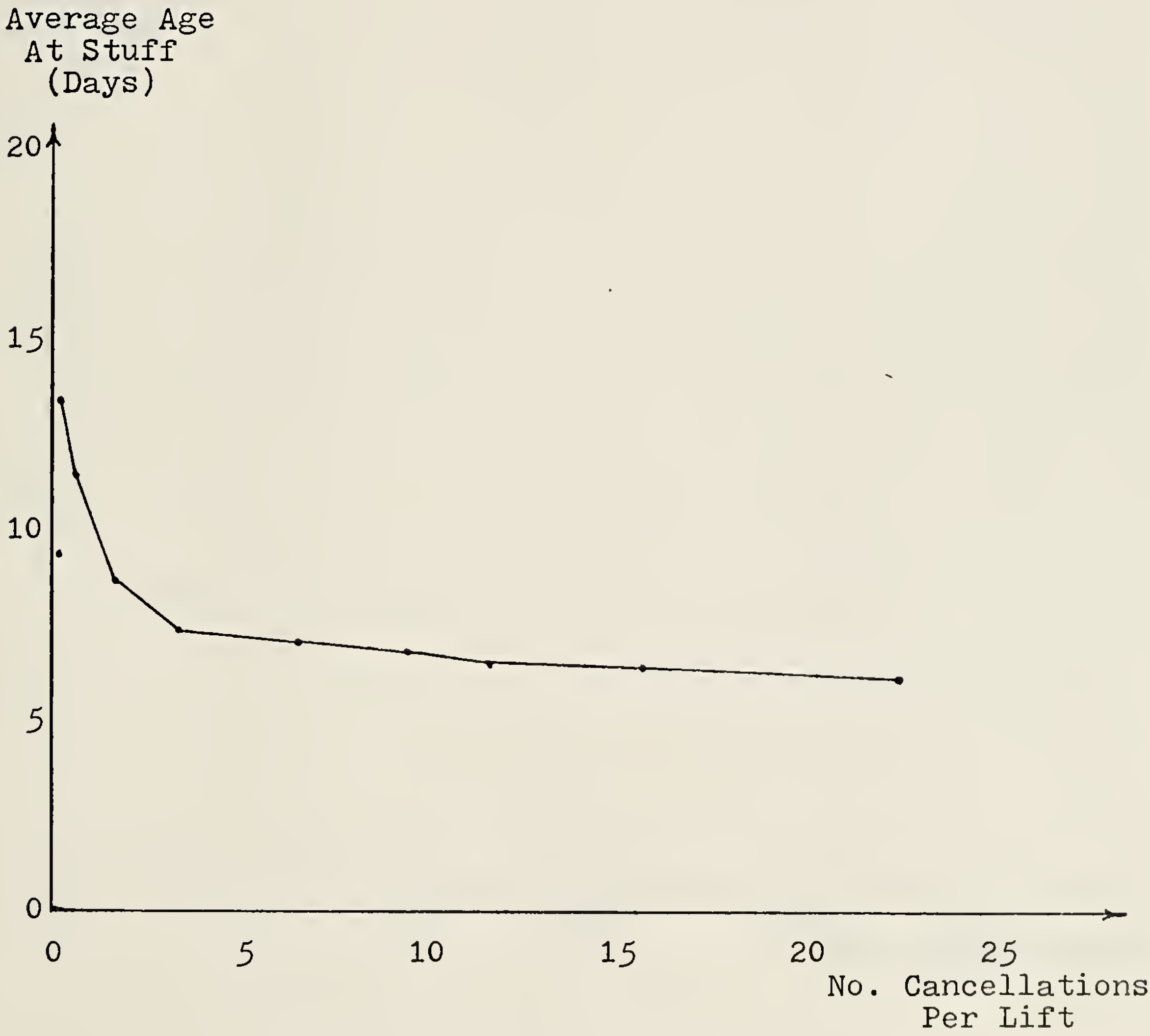
POD: RA3

CFAF	MEAN AGE	CUM. % CHANGE	CUBE UTIL	CHANGE	NO. CANCEL	NO. LIFT	NO. CAN. PER LIFT
0.00	9.41		77.9		32	25	1.28
0.25	12.55		77.7		0	27	0.00
0.50	11.23	-10.52	78.1	.40	0	27	0.00
0.75	10.17	-18.96	77.7	.00	27	25	1.08
1.00	8.67	-30.92	77.8	.10	91	23	3.96
1.25	8.65	-31.08	77.9	.20	205	23	8.91
1.50	8.47	-32.51	77.9	.20	308	23	13.39
1.75	8.32	-33.71	78.0	.30	409	23	17.78
2.00	8.18	-34.82	77.8	.10	518	23	22.52
2.50	8.22	-34.50	77.9	.20	730	23	31.74



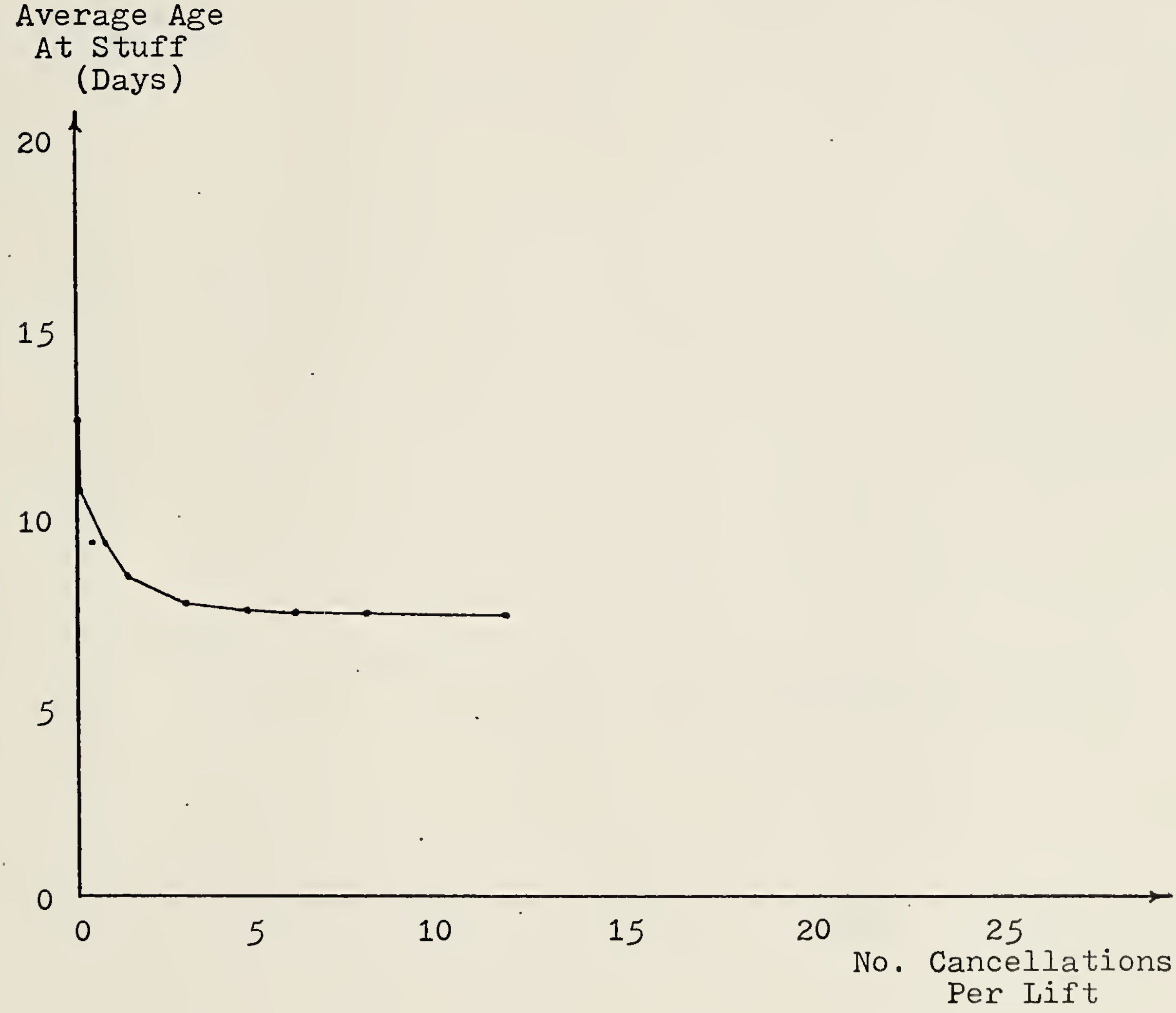
POD: SA1

CFAF	MEAN AGE	CUM. % CHANGE	CUBE UTIL	CHANGE	NO. CANCEL	NO. LIFT	NO. CAN. PER LIFT
0.00	9.12		81.9		6	32	.19
0.25	13.43		82.4		6	38	.16
0.50	11.38	-15.26	83.1	.70	16	35	.46
0.75	8.61	-35.89	81.8	- .60	61	36	1.69
1.00	7.34	-45.35	82.5	.10	114	34	3.35
1.25	7.15	-46.76	82.4	.00	200	31	6.45
1.50	6.91	-48.55	82.2	- .20	299	33	9.06
1.75	6.59	-50.93	81.9	- .50	382	33	11.58
2.00	6.50	-51.60	82.0	- .40	484	31	15.61
2.50	6.37	-52.57	81.6	- .80	713	32	22.28



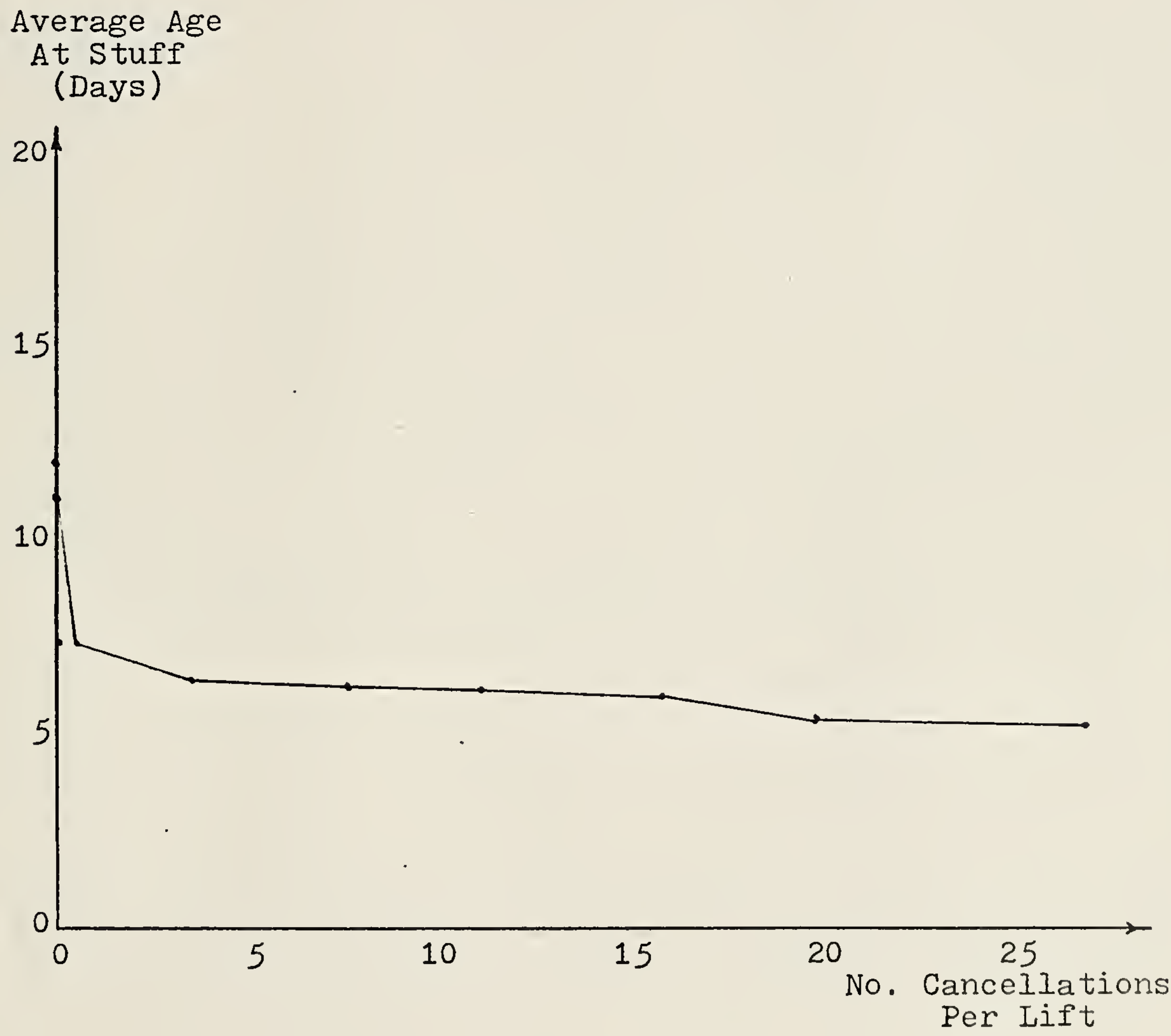
POD: TA2

CFAF	MEAN AGE	CUM. % CHANGE	CUBE UTIL	CHANGE	NO. CANCEL	NO. LIFT	NO. CAN. PER LIFT
0.00	9.27		80.1		9	24	.38
0.25	12.46		80.6		0	27	.00
0.50	10.50	-15.73	80.4	- .20	4	29	.14
0.75	9.25	-25.76	79.5	-1.10	16	29	.55
1.00	8.41	-32.50	79.2	-1.40	39	29	1.34
1.25	7.77	-37.64	78.8	-1.80	76	26	2.92
1.50	7.67	-38.44	78.9	-1.70	109	25	4.36
1.75	7.40	-40.61	78.1	-2.50	151	26	5.81
2.00	7.53	-39.57	78.1	-2.50	183	25	7.32
2.50	7.48	-39.97	78.7	-1.90	267	24	11.13



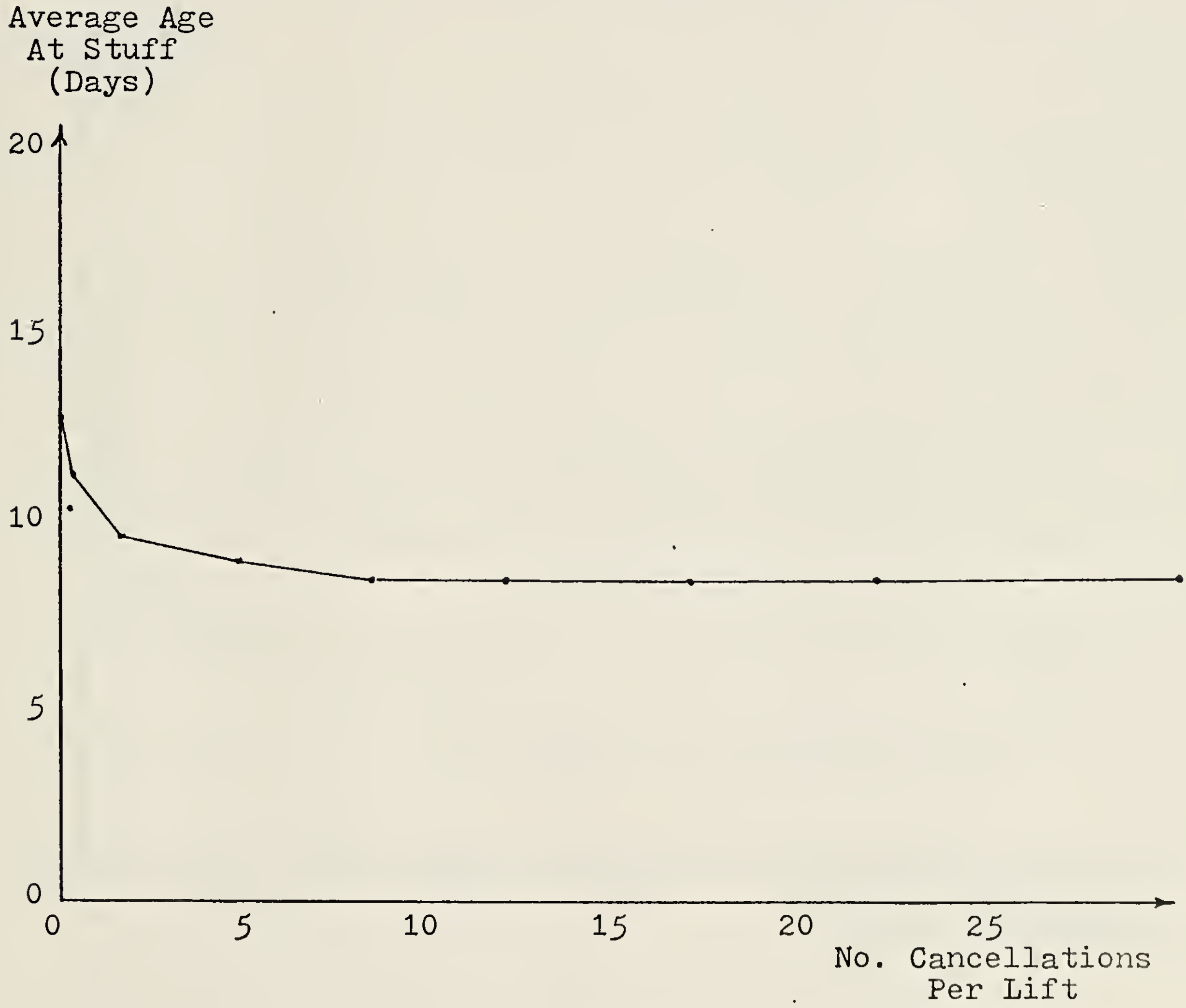
POD: UB1

CFAF	MEAN AGE	CUM. % CHANGE	CUBE UTIL	CHANGE	NO. CANCEL	NO. LIFT	NO. CAN. PER LIFT
0.00	7.64		81.0		2	33	.06
0.25	12.32		82.4		0	34	.00
0.50	11.34	- 7.95	82.3	- .10	0	34	.00
0.75	7.63	-38.07	81.4	-1.00	18	33	.55
1.00	6.82	-44.64	81.0	-1.40	108	31	3.48
1.25	6.66	-45.94	80.8	-1.60	227	30	7.57
1.50	6.49	-47.32	80.6	-1.80	340	31	10.97
1.75	6.12	-50.32	80.8	-1.60	453	29	15.62
2.00	5.74	-53.41	80.4	-2.00	571	29	19.69
2.50	5.54	-55.03	80.5	-1.90	802	30	26.73



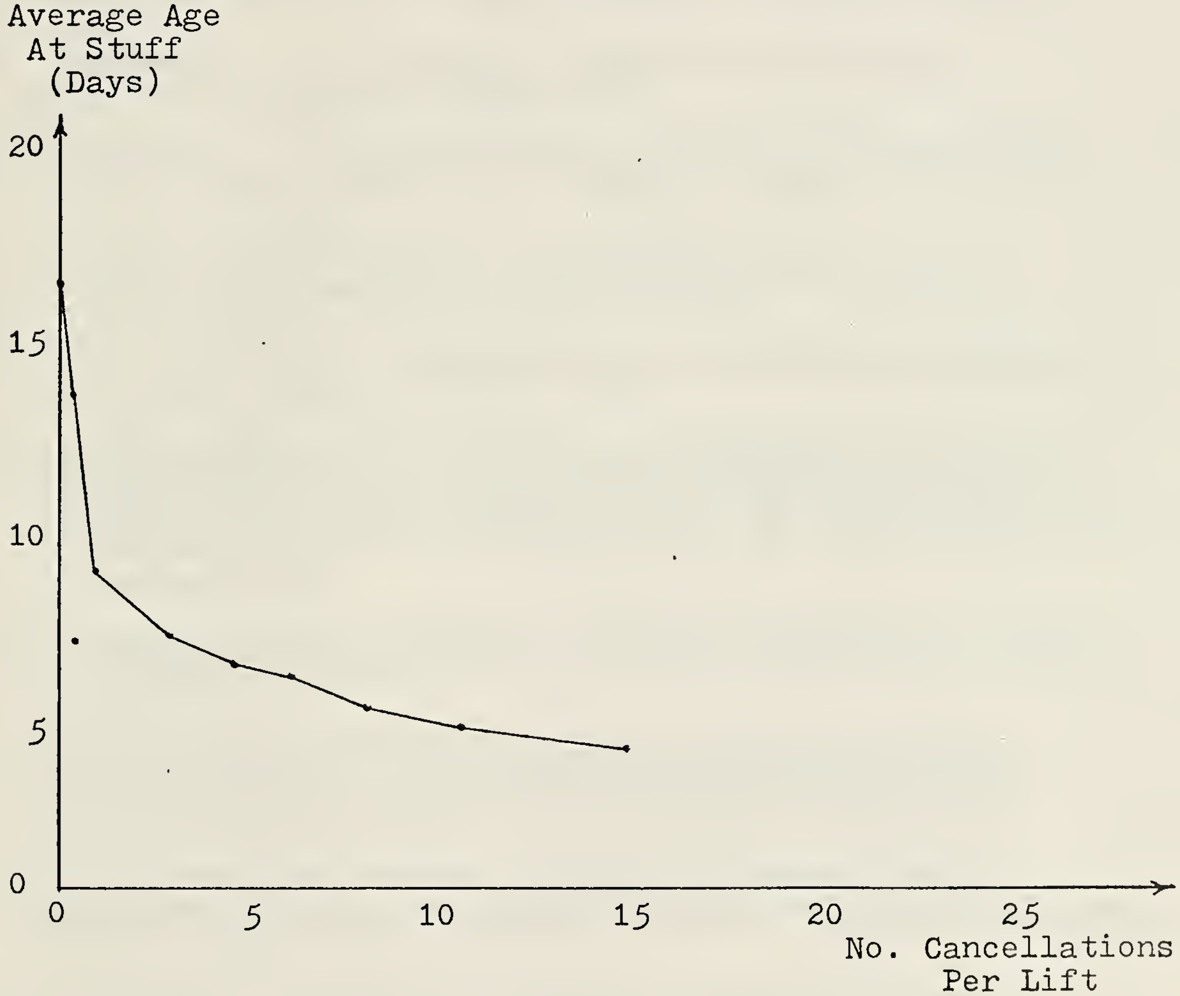
POD: UC2

CFAF	MEAN AGE	CUM. % CHANGE	CUBE UTIL	CHANGE	NO. CANCEL	NO. LIFT	NO. CAN. PER LIFT
0.00	10.67		79.7		4	20	.20
0.25	13.22		79.3		0	21	.00
0.50	11.37	-13.99	79.5	.20	5	24	.21
0.75	9.97	-24.58	78.4	- .90	37	24	1.54
1.00	9.05	-31.54	78.5	- .80	107	23	4.65
1.25	8.79	-33.51	78.5	- .80	179	22	8.14
1.50	8.70	-34.19	78.6	- .70	262	22	11.91
1.75	8.66	-34.49	78.8	- .50	350	21	16.67
2.00	8.66	-34.49	78.8	- .50	454	21	21.62
2.50	8.66	-34.49	78.6	- .70	659	22	29.95



POD: XE2

CFAF	MEAN AGE	CUM. % CHANGE	CUBE UTIL	CHANGE	NO. CANCEL	NO. LIFT	NO. CAN. PER LIFT
0.00	6.04		82.9		26	70	.37
0.25	15.71		83.5		0	83	.00
0.50	12.80	-18.52	83.6	.10	12	80	.15
0.75	8.17	-47.99	83.2	- .30	65	79	.82
1.00	6.58	-58.12	82.3	- .20	189	74	2.55
1.25	5.94	-62.19	81.5	-2.00	318	75	4.24
1.50	5.51	-64.93	81.6	-1.90	434	73	5.95
1.75	4.65	-70.40	81.7	-1.80	584	74	7.89
2.00	4.06	-74.16	81.3	-2.20	752	74	10.16
2.50	3.68	-76.58	80.9	-2.60	1041	72	14.46



LIST OF REFERENCES

1. Container Agreement and Rate Guide, RG-8, Military Sealift Command, 1 July 1974.

2. Department of the Army Contract, No. DAHC23-74-0037, Contracting Officer, WAMTMTS, 1 July 1974.

3. Department of Defense Regulation 4500.32R, Military Standard Transportation and Movement Procedures (MILSTAMP).

4. Department of Defense Supply Management Reference Book, (Washington, D.C.; Government Printing Office, Stk. No. 0807-1555, August 1971).

5. Kushner, H.J., Stochastic Stability and Control, New York, Academic Press, 1967.

6. Lancaster, K., Introduction to Modern Microeconomics, Chicago, Rand McNally and Company, 1968.

7. Pallu de la Barriere, R., Optimal Control Theory, London, W.B. Saunders Company, 1967.

8. Ross, Sheldon M., Introduction to Probability Models, New York, Academic Press, 1972.

9. Systems Analysis of Inland Consolidation Centers for Marine Cargo, U.S. Department of Commerce, National Bureau of Standards Technical Note 530, (Washington, D.C., Government Printing Office, Catalog No. C13.46:530, November 1970).

10. Transportation and Travel, Military Traffic Management Regulation, AR55-355.

11. U.S. Naval Postgraduate School, Technical Report, An Examination of Container Size on Overseas Cargo Distribution Systems, by. J.P. Hynes, March 1974.

12. U.S. Naval Postgraduate School, Technical Report, Stuffing Policies and Transportation Cost Minimization, by J.P. Hynes, April 1974.

13. U.S. Naval Postgraduate School, Technical Report, Container Stuffing Station Simulation Model, by J.P. Hynes, August 1974.

14. Western Area, Military Traffic Management and Terminal Service, <u>Container Conference, 1972</u>, Oakland, California, October 1972.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Documentation Center Cameron Station Alexandria, Virginia 22314	2
2.	Library, Code 0212 Naval Postgraduate School Monterey, California 93940	2
3.	Chief of Naval Personnel, Pers 11b Department of the Navy Washington, D.C. 20370	1
4.	Department Chairman, Code 55 Department of Operations Research and Administrative Sciences Naval Postgraduate School Monterey, California 93940	2
5.	Assistant Professor J.P. Hynes, Code 55Hj (thesis advisor) Department of Operations Research and Administrative Sciences Naval Postgraduate School Monterey, California 93940	1
6.	LCDR. Bert Webster, Code 55WT Department of Operations Research and Administrative Sciences Naval Postgraduate School Monterey, California 93940	1
7.	LT. Thomas R. Nelson, USN E. 804 Brentwood Drive, Rt. 5 Spokane, Washington 99208	1

155601

Thesis
N36684 Nelson
c.1
An analysis of container booking policies for a container stuffing station.